



INSTRUCTIONS

SYSTEMS

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INTRODUCTION

This section presents a diesel-electric locomotive analysis and also covers the various electrical systems on-board the locomotive. Those systems that support the diesel engine are covered in the Engine Support Systems section (Section X).

The intent of this section is to provide an understanding of how individual items of equipment contribute to the functioning of each pertinent system. This will aid maintenance personnel in diagnosing malfunctions and determining the correct procedure to be followed to resolve problems. It also is intended to be used in conjunction with the Trouble-Shooting section (Section XII), the Engine Support Systems section (Section X) and the applicable

locomotive system schematic to diagnose problems when they occur.

It should be noted that variations in the systems will exist between different models of locomotives and between railroad customers. Also, because of the complexity of the systems, liberties have been taken in the method of presentation. Some systems are presented as block diagrams and some as line drawings. One additional system, Engine Systems Monitor (ESM), is presented as a separate entity. In all cases, the diagrams and drawings are intended for the general guidance of personnel.

DIESEL-ELECTRIC LOCOMOTIVE ANALYSIS

The intent of this section is to present a very brief, functional analysis of a diesel-electric locomotive. Fig. VIII-1 reflects the partitioning of the locomotive into five (5) basic areas. The major items of equipment that pertain to these areas are covered elsewhere within the composite maintenance manual.

DIESEL ENGINE POWER SOURCE

The diesel-electric locomotive utilizes an 8, 12 or 16-cylinder, four-stroke diesel engine rated up to 3600 horsepower. The engine and its associated systems are shown in Fig. VIII-2.

POWER TRANSMISSION AND CONVERSION

The power transmission and conversion equipment, Fig. VIII-3, is used to generate a force at the coupler for pulling (or pushing) a train. The mechanical power from the diesel engine is converted to electrical power by a directly-coupled traction alternator. The a-c from the alternator is rectified by the three-phase power rectifier

These instructions do not purport to cover all details or variations in equipment nor to provide for every possible contingency to be met in connection with installation, operation or maintenance. Should further information be desired or should particular problems arise which are not covered sufficiently for the purchaser's purposes, the matter should be referred to the General Electric Company.

Verify numbers for parts, tools, or material by using the Renewal Parts or Tool Catalogs, or contact your General Electric representative for assistance. Do not order from this publication.

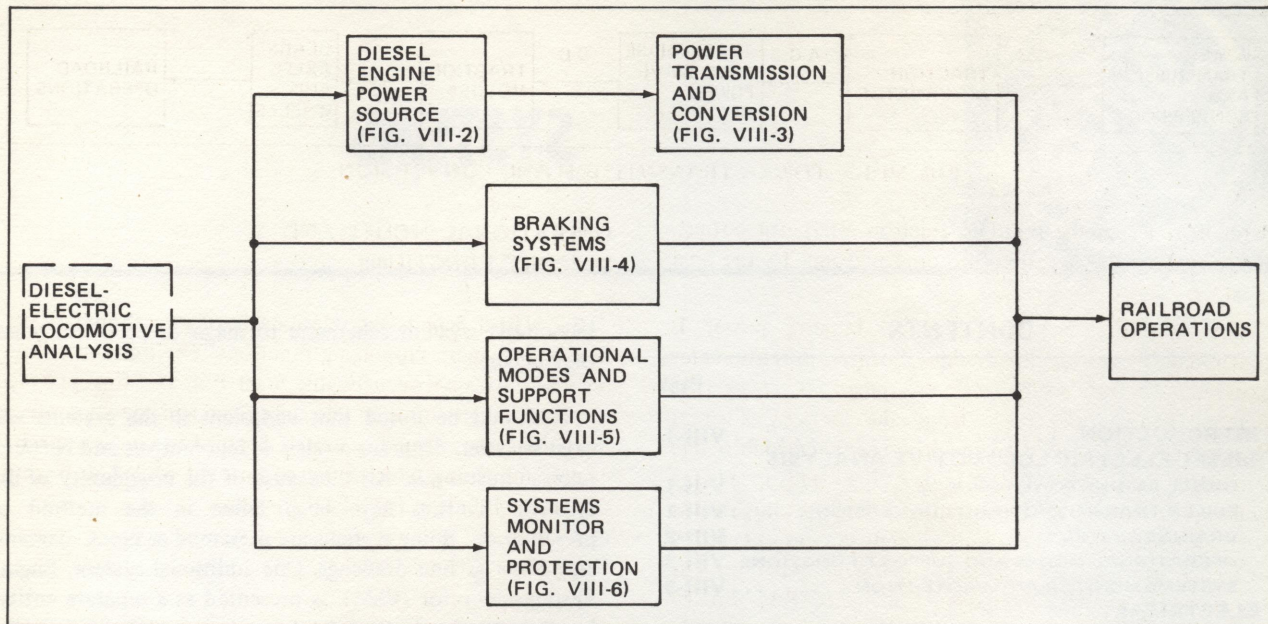


FIG. VIII-1. DIESEL-ELECTRIC LOCOMOTIVE ANALYSIS.

into d-c and transmitted to the traction motors which are geared to the locomotive axles/wheels. Tractive effort developed between the wheels and the rail is transmitted through the locomotive platform to produce the required force at the coupler.

BRAKING SYSTEMS

There are three basic braking systems, Fig. VIII-4, on the locomotive with a fourth system available as a customer option.

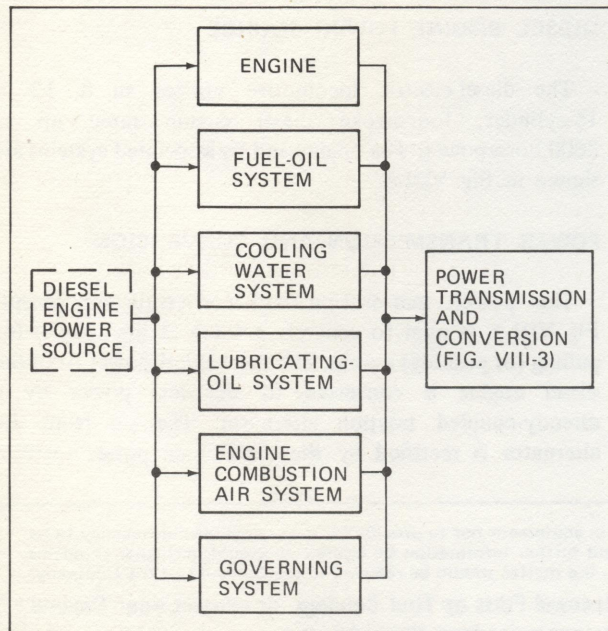


FIG. VIII-2. DIESEL ENGINE POWER SOURCE.

Air Brake

The air brake system regulates the air brake applications, whether Service or Emergency, in proportion to the position of either brake handle. The air brake system utilizes the following equipment and components:

1. An air compressor regulated to maintain air pressure within a preset range in the main reservoirs
2. Two main reservoirs which store a supply of air for the system
3. A brake valve at the operator's position for application of air brakes
4. Tread brake units to provide friction braking on the wheels
5. The necessary piping, pressure switches and control valves for controlled braking.

Dynamic Braking

The dynamic braking system provides a means of reducing train speed by converting inertia into heat energy. This is accomplished by operating the traction motors as generators whose output power is dissipated into resistor grids. Configuration of the traction motor circuits for dynamic braking is controlled by moving the Throttle handle to IDLE position and the Braking handle to SET-UP position. This operates a sequence of interlocking relays and switch contactors which connect the traction motor

FIG. VIII-1, E-25257

FIG. VIII-2, E-25258

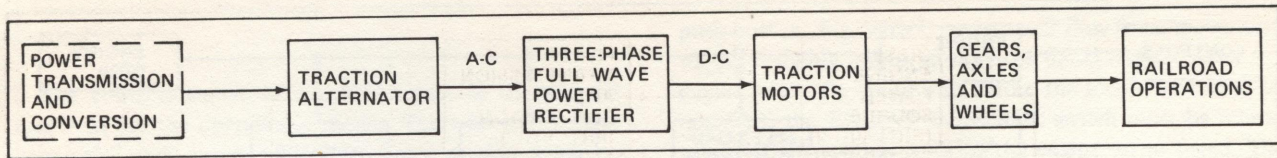


FIG. VIII-3. POWER TRANSMISSION AND CONVERSION.

fields in series to the rectified traction alternator output, and connects the traction motor armatures to the grid resistors.

The magnitude of the dynamic braking power is controlled by setting the braking control potentiometer between the minimum-maximum positions using the Braking handle. Feedback from the Braking Current Reactor (BCCR) is used to measure the magnitude of the current in the braking resistor grid. At high train speeds the braking current is held constant for any setting of the Braking handle by comparing the feedback current with a reference value set by the Braking handle position. The Constant Horsepower Excitation Control (CHEC) circuits adjust the traction motor field current to the value needed to produce the required braking current.

As train speed is reduced, the required field current increases until the rated field current is reached. As train speed is further reduced, the maximum rated traction motor field current is held constant and braking current is reduced linearly with speed.

Blended Braking

Blended braking, which is a customer option, is usually used on high-speed locomotives used in passenger service. Blended braking, basically, is a combination of air and dynamic braking systems.

Handbrake

The handbrake is used primarily as a parking brake and is applied manually. It is a mechanical system.

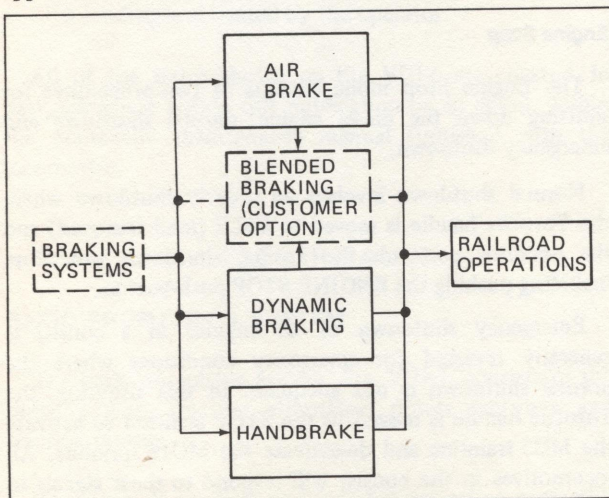


FIG. VIII-4. BRAKING SYSTEMS.

OPERATIONAL MODES AND SUPPORT FUNCTIONS

Fig. VIII-5 depicts the relationship of several operational modes and their supporting functions. The horizontal line on Fig. VIII-5 between Engine Start/Run and Engine Stop may be thought of as an idle state from and to which other modes may be entered or exited. Motor Cut-Out is a special case of motoring which may be entered while the Engine Control switch is in the START position.

Engine Start/Run

The function of the Engine Start/Run subsystem is to provide the switches, circuit breakers and relay interlocks needed to configure the starter, generator, pre-lube pump and fuel pump for starting and running the diesel-engine.

Motor Cut-Out

The Motor Cut-Out operation is an optional capability to allow motoring with one (or more) traction motor(s) electrically disconnected from the traction-alternator power output circuit. This mode of operation may be necessary if for some reason a malfunction in the traction motor circuitry prevents normal motoring operation. On six-axle locomotives, traction motors are usually cut-out in pairs.

Self-Load

The Self-Load mode is an optional capability provided to allow testing of the locomotive under load without actually developing tractive effort.

In this mode, the grid resistors normally used in dynamic braking are used as a load for the traction alternator output and power to the traction motors is disconnected. Interlocking is provided to prevent switching into or out of self-load while under power. Also, while in the self-load mode, engine speed and excitation control continue to function as in normal motoring.

Motoring

The function of the Motoring mode of operation is to provide the throttle controls, relays, logic and reference circuits needed to control powered operation of the locomotive.

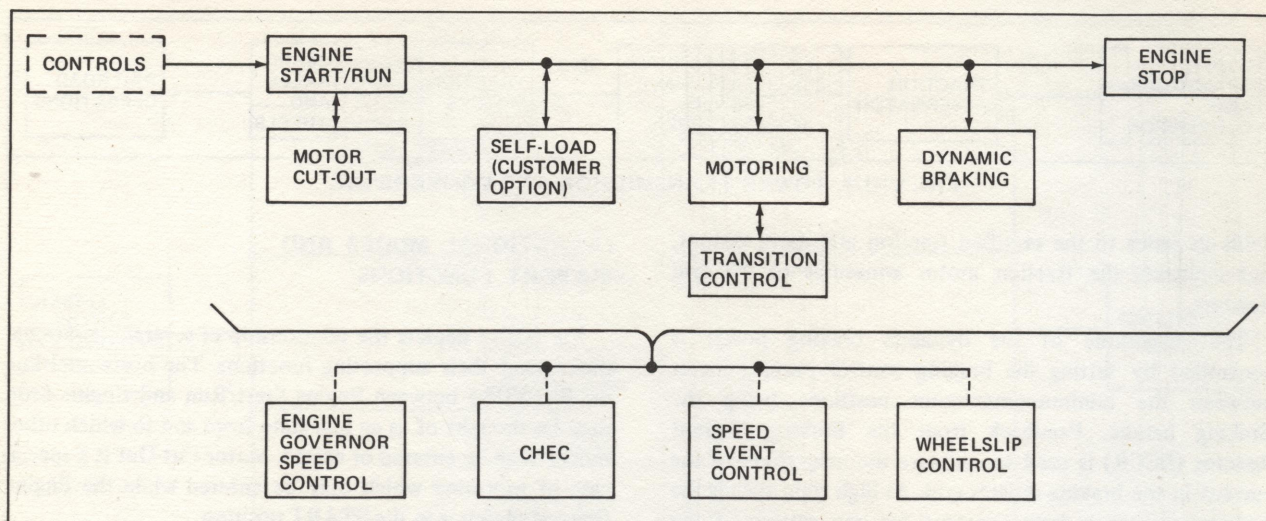


FIG. VIII-5. OPERATIONAL MODES AND SUPPORT FUNCTIONS.

The Throttle handle located on the operator's control console has eight notch settings plus IDLE and STOP. Movement of the Throttle handle controls the diesel engine speed for each notch setting, sets current, voltage and power limits for each notch setting and provides control relay interlocks for the motoring functions.

The Reverse handle located on the operator's control console has two positions; FORWARD and REVERSE. These two positions control the direction of travel of the locomotive by setting the Reverser switch contactors in the FORWARD or REVERSE position.

Transition Control

The function of the Transition Control mode is to change the configuration of the traction motors from a series-parallel configuration to an all-parallel configuration when the locomotive increases speed above the transition speed point (approximately 25 mph). It will also change from an all-parallel configuration to a series-parallel configuration when the locomotive decreases speed 2 mph (approximately) below the transition speed point.

The transition control circuit senses locomotive speed from an axle-mounted alternator which develops a signal proportional to locomotive wheel speed. This speed signal is compared with a reference speed signal within the Speed Event Panel and the output of this comparison function then generates a transition control signal that initiates the transition action.

The reason for having a transition control circuit is because very high traction motor currents are required to initially start the train moving. Conversely, very high motor voltage is required to operate the train at the higher speeds.

(The motoring operation covers train speeds up to approximately 70 mph.) In order to reduce the output requirements of the traction alternator to practical values of current and voltage, the traction motors are operated in a two-series/two-parallel configuration for four-axle locomotives (two-series/three-parallel for six-axle locomotives) at low train speeds and in a four-parallel (six-parallel for six-axle locomotives) at high train speeds. The transition control circuitry provides the mechanism for switching back and forth between the series-parallel and parallel configurations as the train speed varies.

Dynamic Braking

The Dynamic Braking mode has been explained in the Braking Systems section. It operates through the CHEC system to control the magnitude of the braking current and to limit the current in the field of the traction motors to a rated value.

Engine Stop

The Engine Stop mode consists of two procedures for shutting down the diesel engine; normal shutdown and emergency shutdown.

Normal shutdown involves an orderly shutdown where the Throttle handle is moved to IDLE (load removed) and the operator performs the normal shutdown procedure including pushing the ENGINE STOP push-button.

Emergency shutdown of all engines in a consist is generally reversed for emergency conditions where the normal shutdown is not adequate. In this situation, the Throttle handle is moved to the STOP position to activate the MU3 trainline and de-activate the MU16 trainline. All locomotives in the consist will respond to these signals to cause engine shutdown.

Controls

The controls shown in Fig. VIII-5 provide the support functions for the operational modes. There are many more "controls" that support the operational modes; however, the Engine Governor Speed Control, CHEC, Speed Event Control and Wheel slip Control may be considered as major control circuits. Each of these is explained in detail elsewhere within this publication.

SYSTEMS MONITOR AND PROTECTION

The monitor, alarms and controls systems for engine and crew protection are shown in Fig. VIII-6. As stated before, this is a very brief functional analysis of the overall locomotive systems monitor and protection events. For a more comprehensive explanation of the monitoring of the engine systems, refer to the ENGINE SYSTEMS MONITOR section.

Fig. VIII-6 covers four major categories:

1. Monitors and controls that serve the purpose of warning the operator
2. Monitors and controls that cause the engine to unload and return to idle speed
3. Monitors and controls that cause a reduction of excitation and load to meet the unit's capabilities (system derated)
4. Monitors and controls that cause the engine to shut down.

One additional control (sanding) is included in Fig. VIII-6. An indication (status) light will be lit when manual sanding is activated by the operator.

All of the items shown on Fig. VIII-6 are covered, in part, elsewhere within this publication or, in detail, within the composite maintenance manual furnished with the locomotive.

ELECTRICAL

BASIC PROPULSION SYSTEM

The basic propulsion system, Fig. VIII-7, consists of the diesel engine, traction alternator, power rectifiers and traction motors.

Assuming all controls and switches are set-up correctly, when the operator pushes the ENGINE START

push-button, Fig. VIII-7, current will flow from the battery to the cranking motor to start the diesel engine. After the engine is at idle speed and before the locomotive is to be operated, the ENGINE CONTROL switch must be moved to the RUN position to bring the engine up to speed. The locomotive is now ready for the operator to apply propulsion power by operating the Master Controller.

The diesel engine is mechanically coupled to the traction alternator. The traction alternator is a rotating machine which converts the mechanical energy from the diesel engine into electrical energy. This electrical energy consists of three-phase a-c which is rectified by three banks of power rectifiers; one bank for each phase. The resultant d-c is then applied to the traction motors. The function of the traction motors is to convert the d-c electrical energy into mechanical power for driving the locomotive wheels.

BASIC CONTROL SYSTEM

The basic control system, Fig. VIII-8, provides the means of controlling the propulsion system during the motoring operation. It should be noted that the braking system mode is not shown on Fig. VIII-8, but is covered elsewhere within this publication.

The major equipment for control consists of the Master Controller, CHEC Panel, exciter, CMR Wheel slip Detection Panel, current measuring reactors, axle alternator and the Speed Event Panel.

The Master Controller enables the operator to initiate operation of the propulsion equipment by operating the Throttle handle (also the Reverse handle). The Throttle handle notch signals are then applied to the CHEC Panel.

The CHEC Panel functions as an electronic control center for control signals and power requests. It analyzes numerous signals from equipment such as the Master Controller, CMR Wheel slip Detection Panel, current measuring reactors and the diesel engine. In addition, the CHEC Panel receives transition signals from the transition control circuit. This circuit senses locomotive speed from an axle-mounted alternator which develops a signal proportional to locomotive wheel speed. This speed signal is compared with a reference speed signal within the Speed Event Panel and the output of this comparison function then generates a transition control signal which is sent to the CHEC Panel to place the traction motors in either a series-parallel or parallel configuration. The CHEC Panel then utilizes the various signals to regulate the propulsion system to obtain maximum efficiency in applying propulsion power to the wheels. This is accomplished, basically, by supplying a regulated, variable current to the exciter's shunt field thereby controlling the excitation

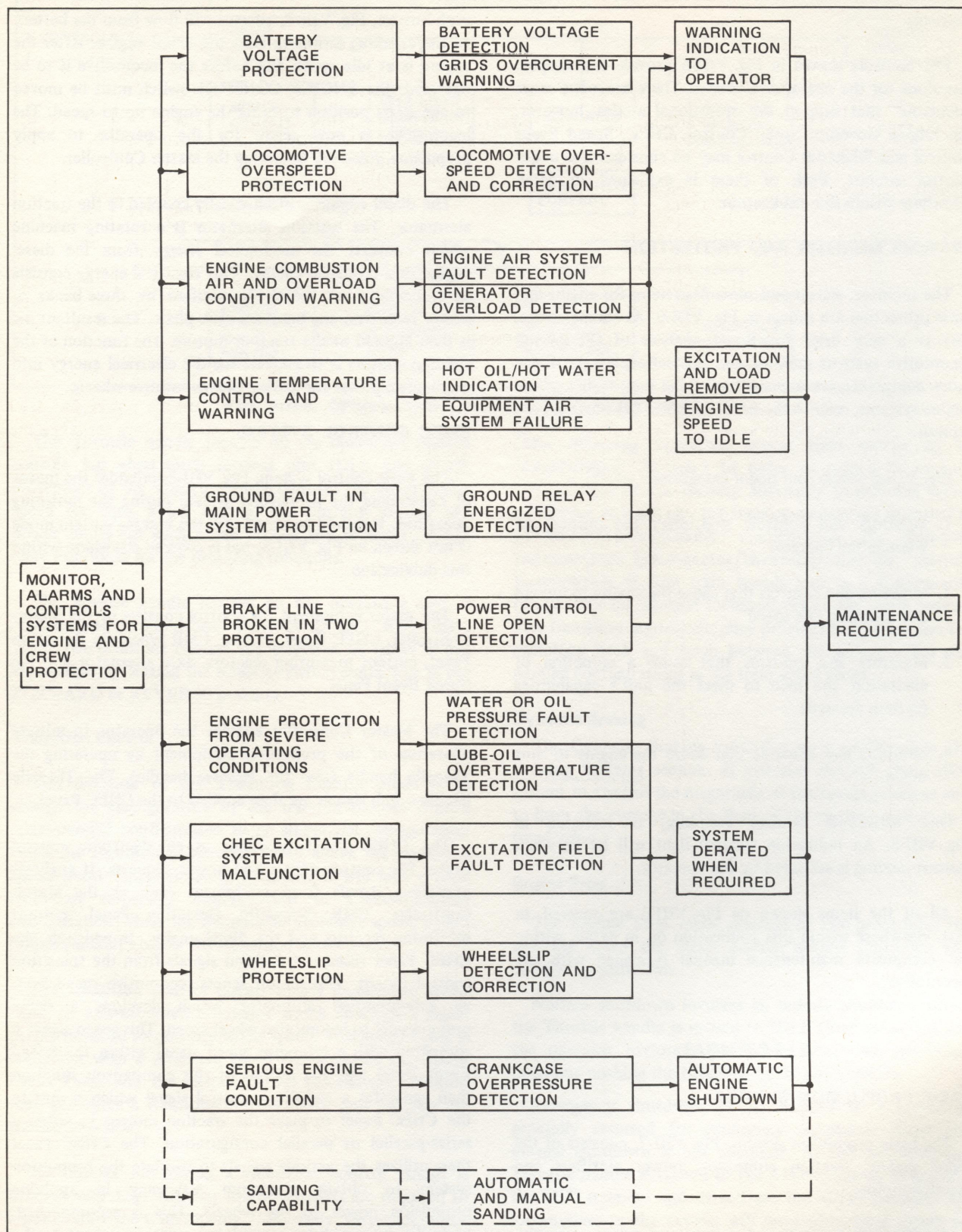


FIG. VIII-6. SYSTEMS MONITOR AND PROTECTION.

FIG. VIII-6, E-25262

FIG. VIII-7, E-25263

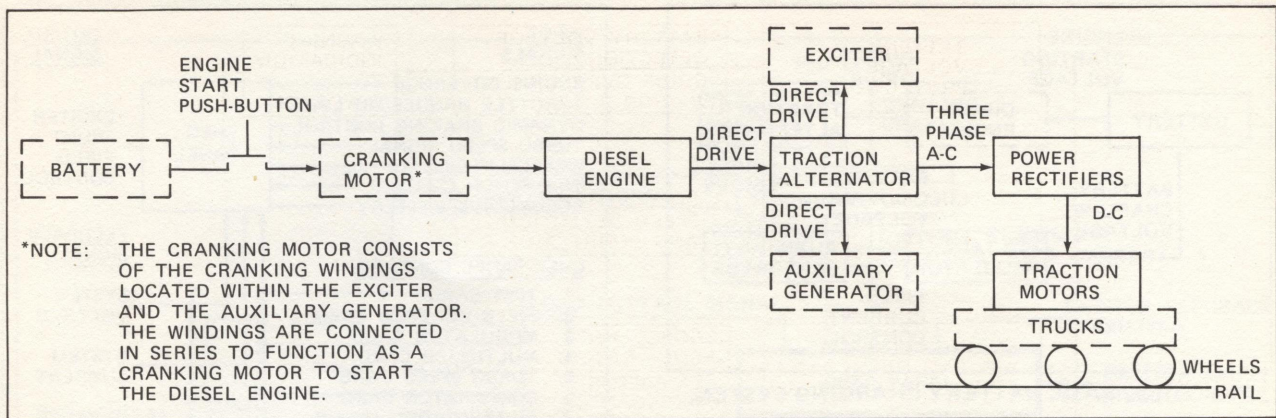


FIG. VIII-7. BASIC PROPULSION SYSTEM.

current to the field of the traction alternator. Thus, the traction alternator output to the traction motors is controlled during motoring (propulsion, transition and wheelslip).

BASIC BATTERY CHARGING SYSTEM

The basic battery charging system, Fig. VIII-9, consists of the battery, auxiliary generator and voltage regulator.

The battery is used to supply electric power for diesel engine starting and auxiliary electrical power for when the diesel engine is shutdown. After the battery has been used to start the diesel engine and the engine and traction alternator have reached running speed, the auxiliary generator which is driven by a gear box mounted on the traction alternator, will provide battery charging d-c voltage to the voltage regulator.

FIG. VIII-8, E-25264

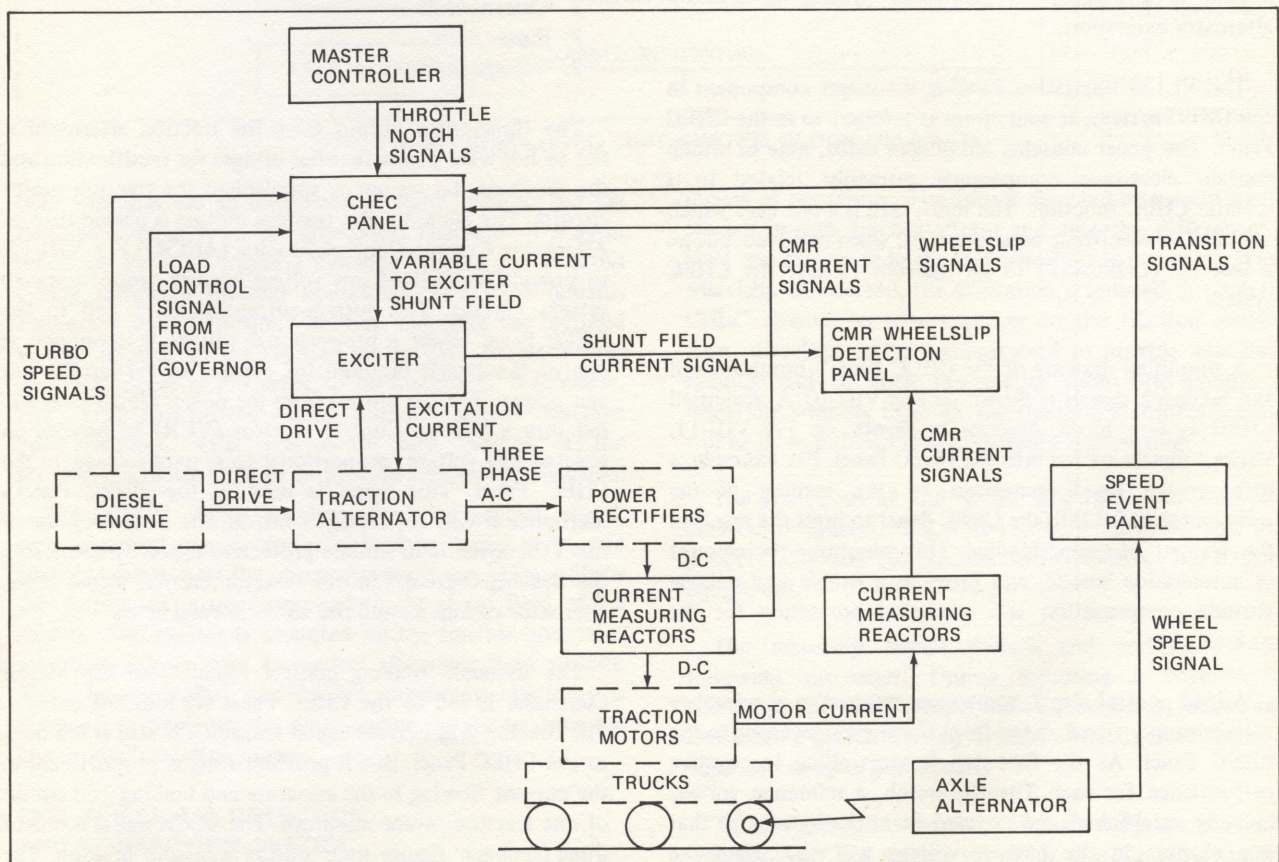


FIG. VIII-8. BASIC CONTROL SYSTEM.

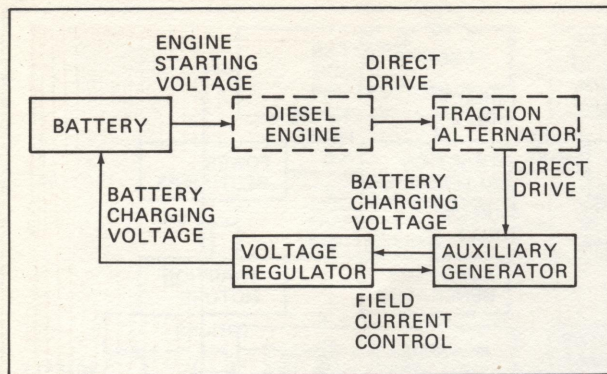


FIG. VIII-9. BASIC BATTERY CHARGING SYSTEM.

The voltage regulator controls the output from the auxiliary generator by sensing the generator output and adjusting the field current of the generator to maintain +74 vdc under various conditions of load and of diesel engine rpm. This 74 volts is then supplied to the battery as a charging voltage.

CHEC SYSTEM

The Constant Horsepower Excitation Control (CHEC) system is a method of electronic control of traction alternator excitation.

The FL138 Excitation Panel is the major component in the CHEC system. It sometimes is referred to as the CHEC Panel. The panel contains ten plug-in cards, nine of which contain electronic components primarily related to a specific CHEC function. The tenth card is a test card which contains no electronic apparatus but, when removed, allows a test kit (CHECKIT) to be inserted to test the CHEC system.

A simplified drawing of the CHEC Panel's input, output and feedback signals is shown on Fig. VIII-10. A simplified CHEC system block diagram is shown on Fig. VIII-11. Various signals are fed into the CHEC Panel. For example, a turbo speed signal generated by the turning of the turbo-rotor is fed into the CHEC Panel to limit the rate and the amount of engine loading. This minimizes the amount of acceleration smoke, and provides a simple and reliable altitude compensation and overspeed protection for the turbocharger.

A load control signal, sometimes referred to as reference voltage-supply signal, is fed from the engine governor to the CHEC Panel. As the first step in controlling locomotive performance for each Throttle notch, a reference voltage must be established and isolated from the battery so that any changes in the battery voltage will not affect the reference voltage. This reference-voltage signal and the

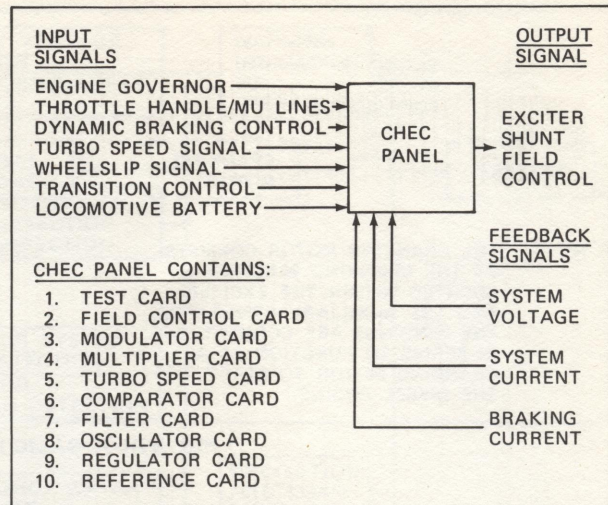


FIG. VIII-10. CHEC PANEL'S INPUT, OUTPUT AND FEEDBACK SIGNALS.

notching control signal from the Master Controller are fed to the CHEC Panel via the trainline circuits. Three reference-voltage signals are established for each notch.

1. Current limit
2. Power limit
3. Voltage limit.

The three-phase output from the traction alternator is fed to full wave power rectifier bridges for rectification and the resultant d-c output is supplied to the traction motor circuits. The d-c from the traction motors is passed thru an Alternator Current Control Reactor (ACCR), Fig. VIII-12, to provide an isolated low voltage current proportional to system current. This system-current signal is fed to the CHEC Panel where a proportional voltage is developed as one of the signals required for control of system current and power. The d-c output from the power rectifiers is also fed thru a Voltage Control Reactor (VCR) to provide an isolated low voltage, proportional to system voltage, to the CHEC Panel. This signal is used in the CHEC Panel's multiplier circuit for voltage control. The secondary use of the VCR signal is to initiate protective action by overriding the Braking-Current Control Reactor (BCCR) signal if the alternator voltage should rise above normal value.

The dynamic braking control signal from the Master Controller is fed to the CHEC Panel via trainline circuits. The braking grid current signal from BCCR also is fed back to the CHEC Panel. BCCR provides a signal proportional to the current flowing in the armature and braking grid circuit of one traction motor armature. The BCCR signal is one of three feedback signals used during dynamic braking. The other two are from ACCR and VCR. The traction-motor

FIG. VIII-9, E-25265

FIG. VIII-10, E-25266

FIG. VIII-11, E-25267

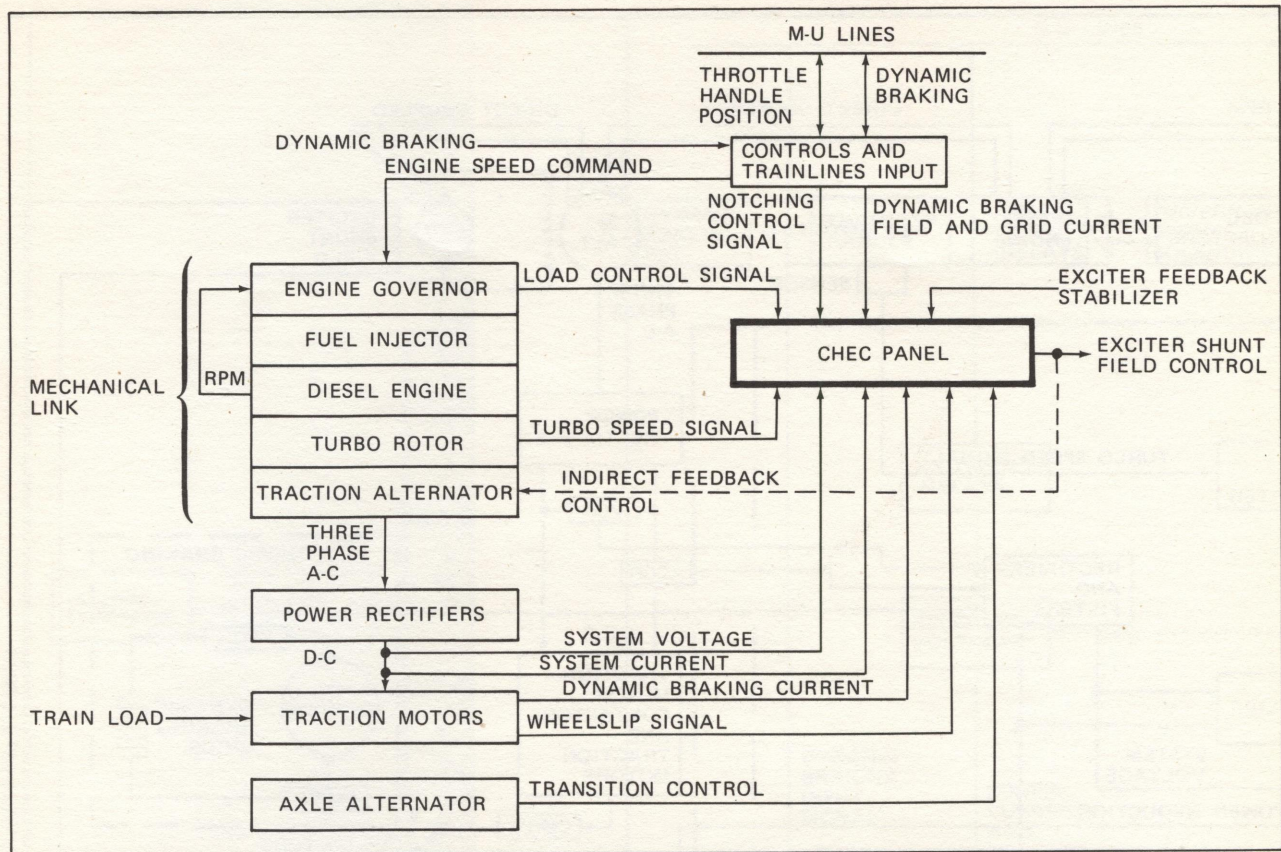


FIG. VIII-11. SIMPLIFIED CHEC SYSTEM BLOCK DIAGRAM.

field windings are all connected in series, and are fed the rectified current from the alternator. This current is again measured by ACCR during dynamic braking just as it did during motoring (power) operations. The VCR remains connected during dynamic braking, but since the rectified voltage applied to the traction-motor field circuit is low, the VCR signal is too weak to be functional. If however, the traction-motor field circuit should become open-circuited, VCR will come into control of the traction-alternator voltage to provide a protective function.

The CHEC Panel receives the turbo-speed signal, system-current signal, dynamic braking signal, etc., and after considering all the circumstances it can sense, adjusts the amount of current supplied to the shunt field of the exciter. The exciter is mounted on the traction-alternator gear box and is used to control alternator field current. Thus, by controlling the exciter, maximum efficiency is obtained in applying the diesel-engine output to drive the locomotive's traction motors.

CMR WHEELSLIP DETECTION AND CORRECTION SYSTEM

The function of wheelslip control is to detect and correct for wheelslips in both motoring and dynamic braking

modes of operation. Wheelslip is detected by measuring the current in each traction motor and detecting differences in level and rate to indicate that wheelslip is occurring. When wheelslip is detected, the excitation is reduced through the CHEC circuits to reduce power to the traction motors. Also, wheelslip relays are energized to provide automatic sanding and to open the exciter shunt-field circuit. A wheelslip warning light on the operator's control console will be lit to indicate that a wheelslip is occurring.

The function of the CMR wheelslip detection and correction system, Fig. VIII-13, is to provide the best possible adhesion for traction and to protect the traction equipment.

The wheelslip circuit detects and corrects for the following anomalies: During motoring it corrects for wheelslip, open or improper motor connection, locked axle and slipped pinion. During dynamic braking it corrects for wheelslip or open grid circuit.

Three types of corrections for wheelslip are provided. One for short and sudden wheelslip, one for a more lasting and severe wheelslip and a third one to guard against overspeed and simultaneous slip.

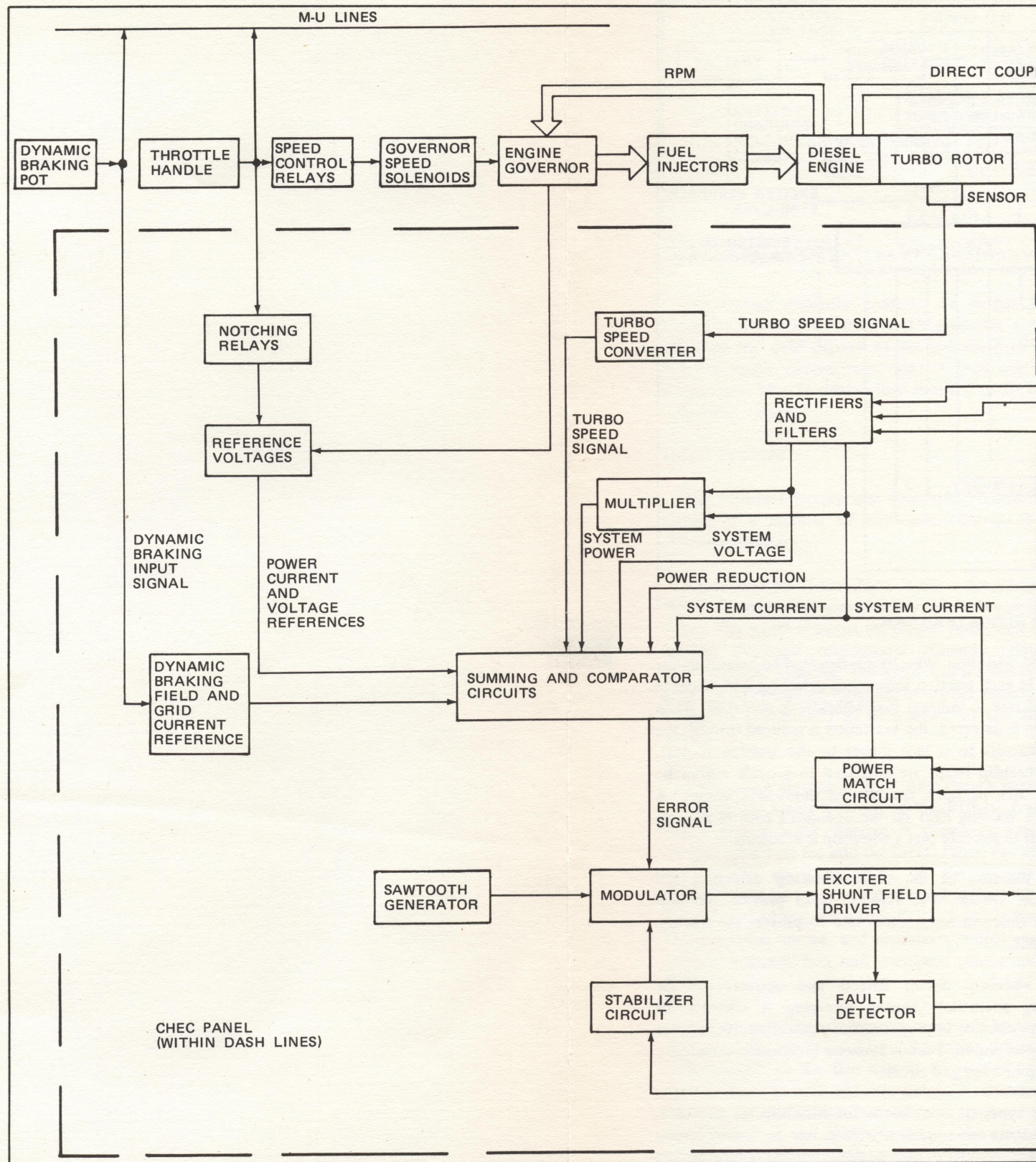


FIG. VIII-12. CHEC SYSTEM BLOCK DIAGRAM.

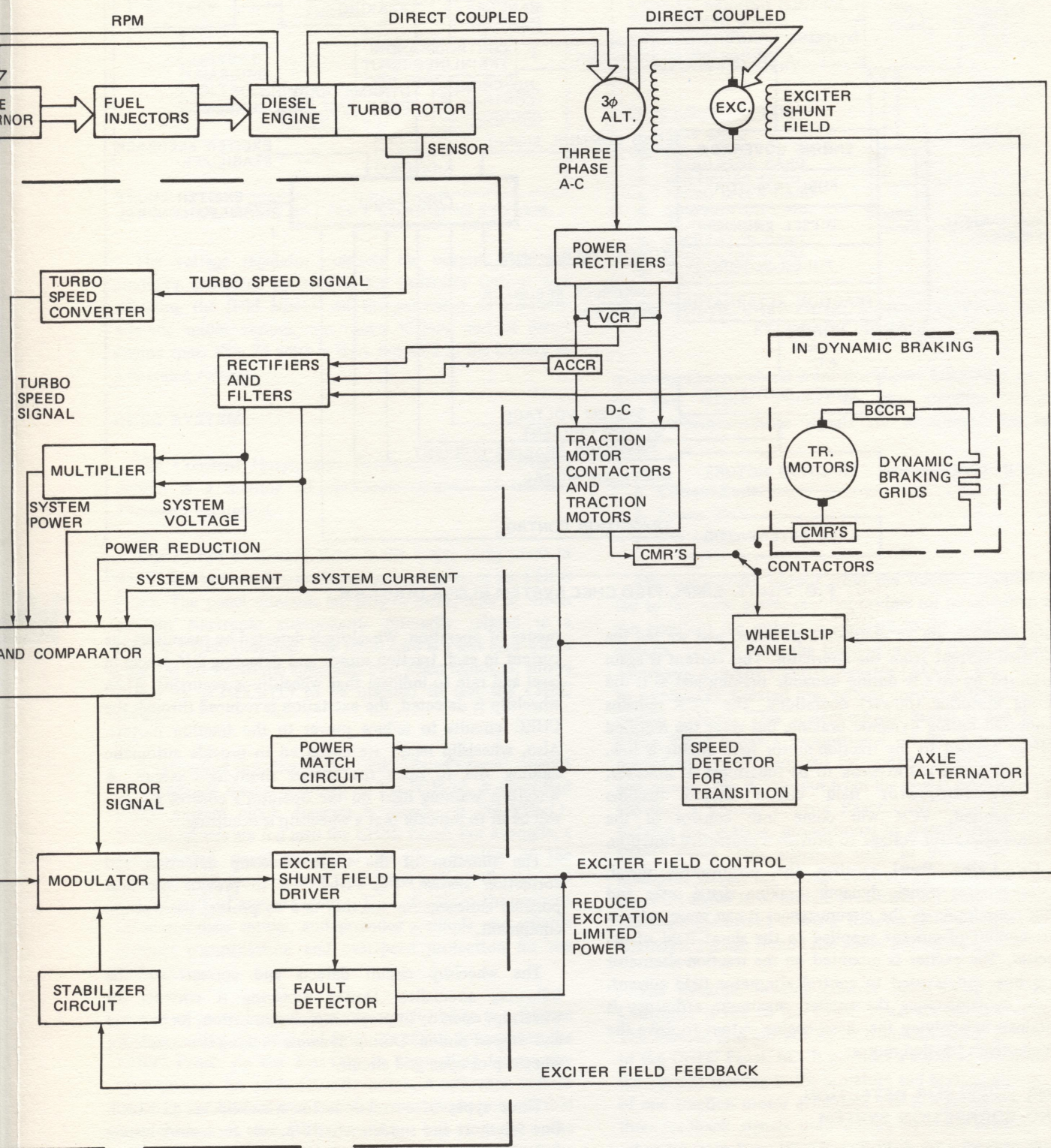
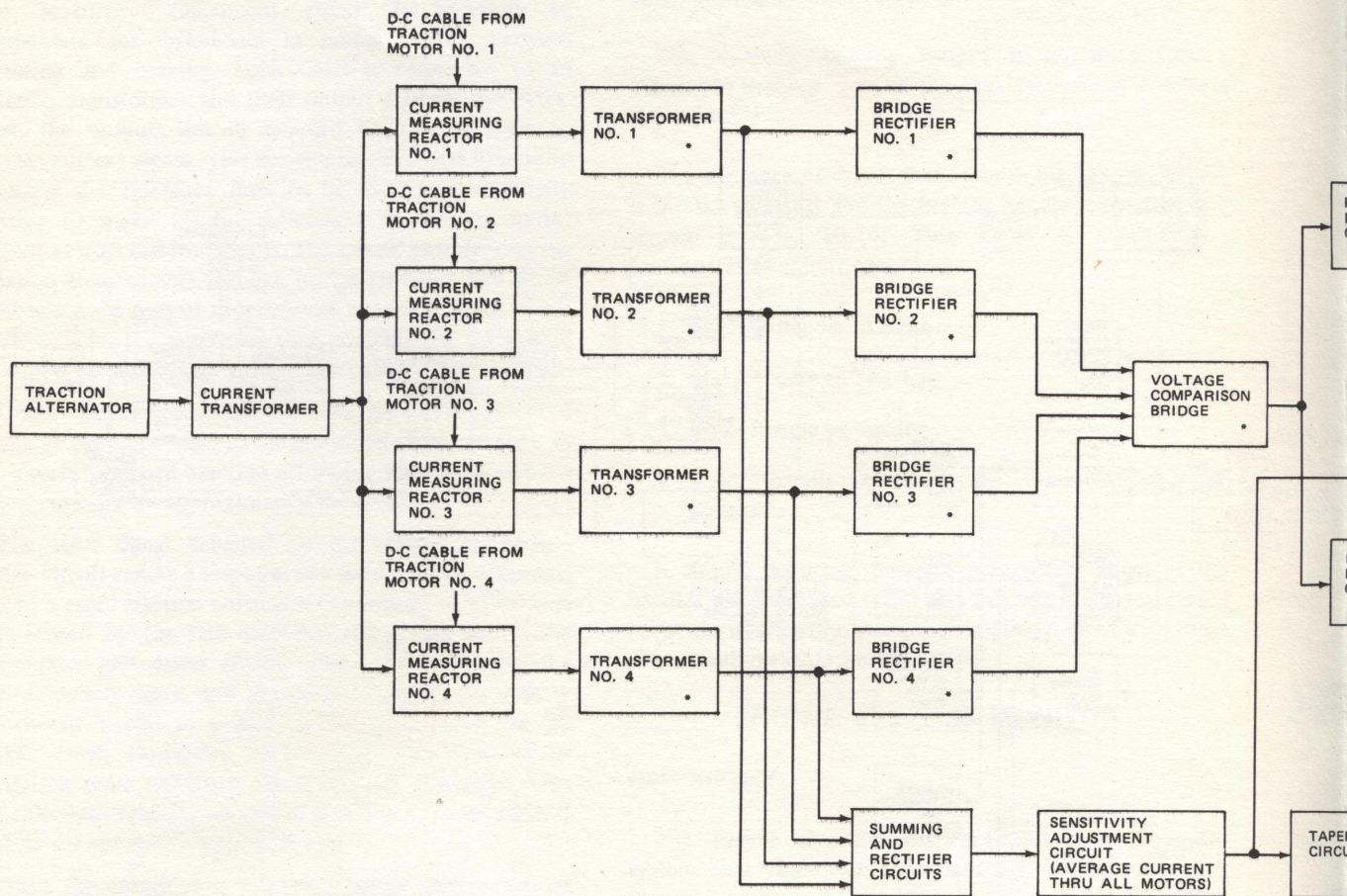


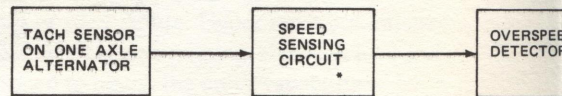
FIG. VIII-12, E-25268

FIG. VIII-13, E-25269



NOTE:

1. THIS DIAGRAM IS FOR A "B" LOCOMOTIVE.
2. AN ASTERISK (*) INDICATES COMPONENTS OR CIRCUITS THAT ARE PART OF THE FL84 CMR WHEELSLIP PANEL (OR THE FL80 CMR WHEELSLIP PANEL ON A "C" LOCOMOTIVE).
3. WHEELSLIP CIRCUIT FOR DYNAMIC BRAKING IS NOT SHOWN.



SYNCHRONOUS SLIP, OVERSPEED DETECTION AND

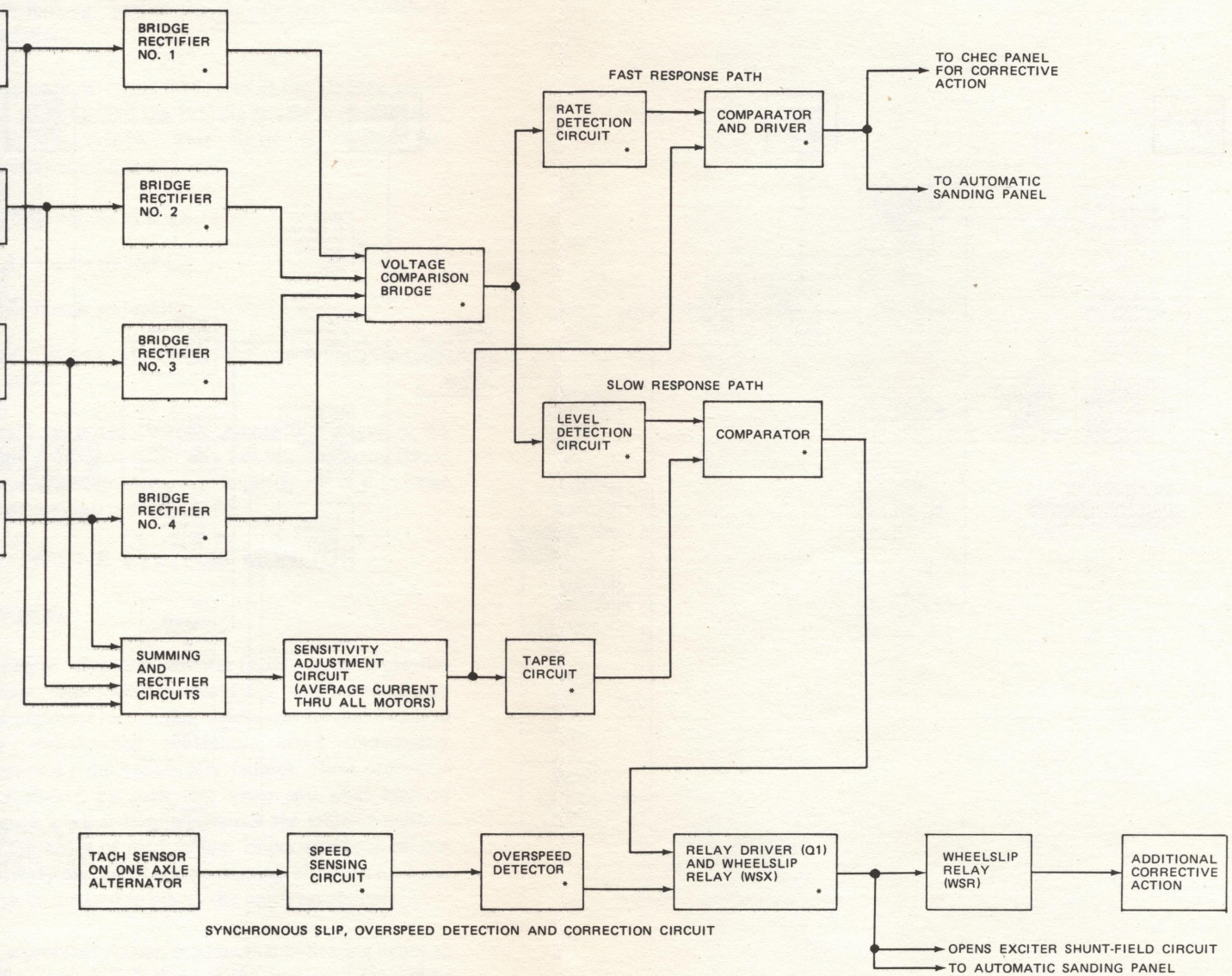


FIG. VIII-13. CMR WHEELSLIP DETECTION AND CORRECTION SYSTEM.

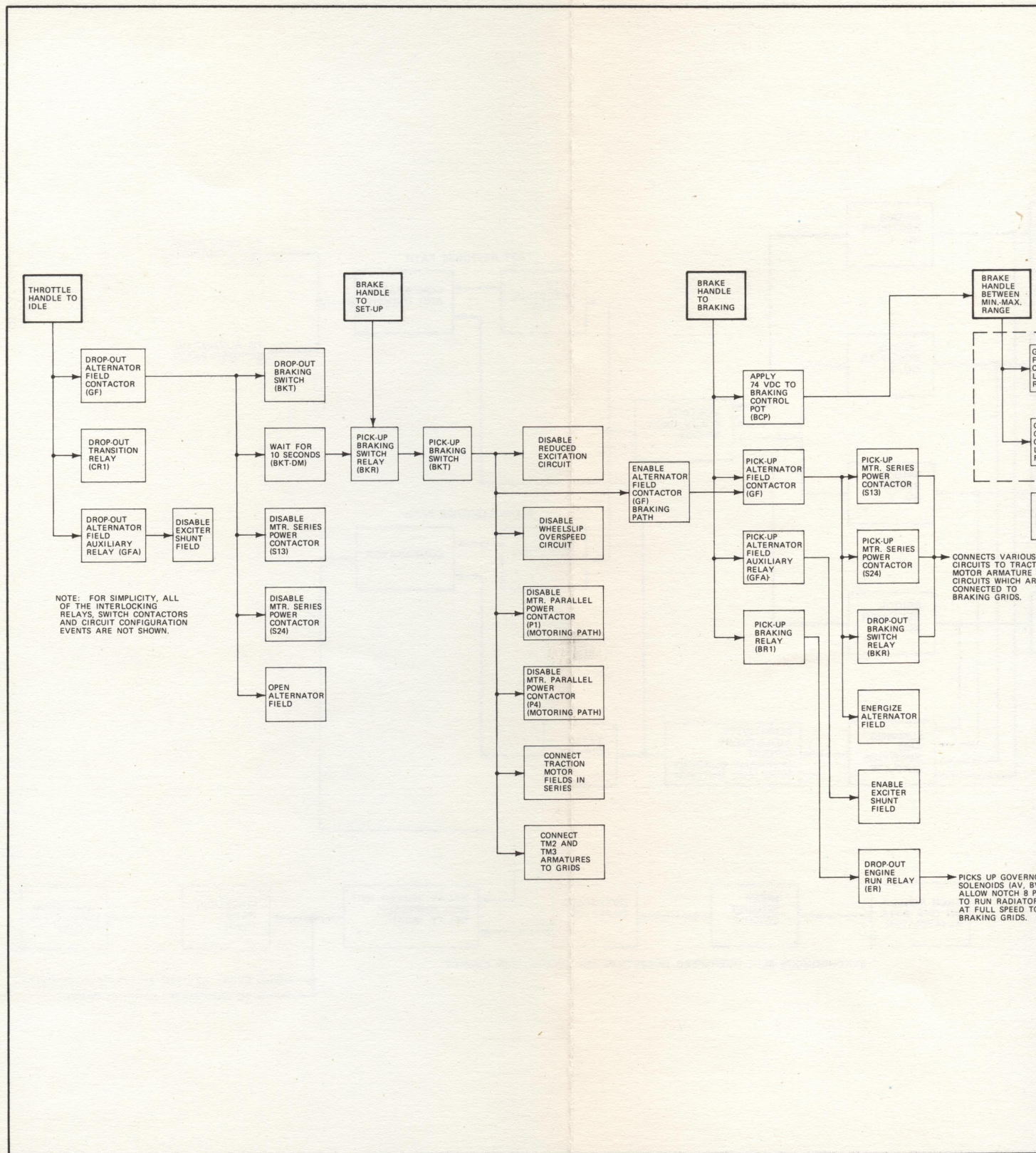


FIG. VIII-14. DYNAMIC BRAKING SYSTEM BLOCK DIAGRAM OF EVENTS.

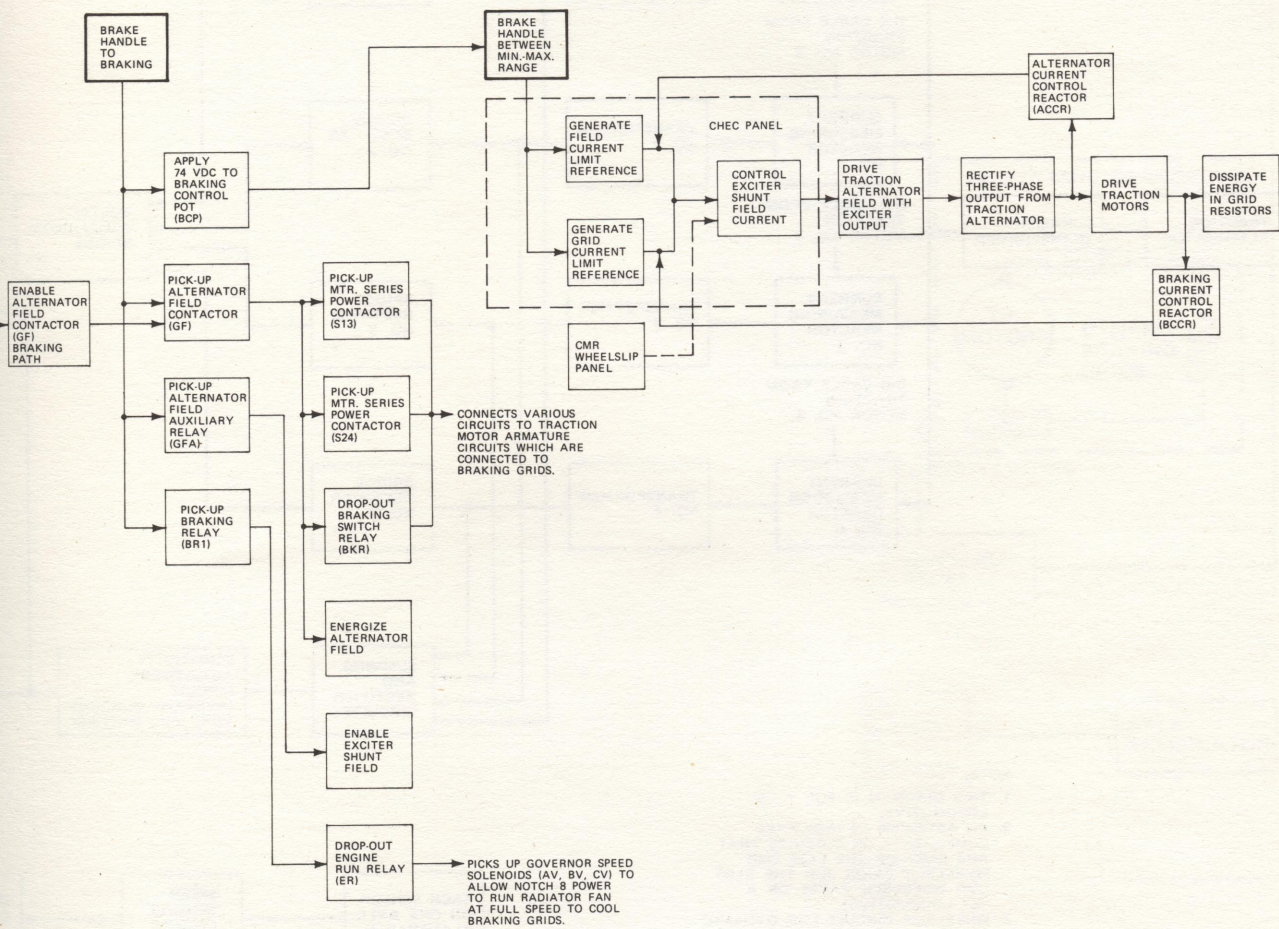


FIG. VIII-14, E-25270

The first two types of wheelslip detection employ Current Measuring Reactors (CMR's) to monitor the current through each traction motor. Power for the CMR's is developed through a current transformer connected to one of the three phases of the traction alternator. The output of the current transformer is then fed to the CMR's.

A sensitivity adjustment circuit is necessary to compensate for differences in motor current between motoring and braking. Each CMR is connected to an isolation transformer and their output follows two paths. First, the outputs are all summed together to form an average current signal. This signal is rectified and filtered to obtain a d-c reference level to be used as a sensitivity control to make up for differences in traction motor current at high and low speeds. The second path is from the isolation transformers through bridge rectifiers and filters to obtain a d-c output proportional to each traction motor current. These d-c signals are then compared to a precision reference voltage in the voltage comparison bridge circuit.

Under normal operating conditions, the tractive effort of each axle is proportional to the individual motor current, so for closely matched traction effort (or braking effort) the motor currents are approximately the same.

The error signal detected by the voltage comparison bridge circuit can be a response to a sudden surge in current due to a rapid traction unbalance (wheelslip), in which case it is sensed by the rate detection circuit and fed to the comparator and driver circuit. This circuit compares the rate detection signal and the output from the sensitivity adjustment circuit to provide a correction signal to the CHEC Panel. Corrective action is in the form of an excitation pulse reduction signal. Also, if the signal from the rate detection circuit lasts more than three seconds, it enables the automatic sanding circuit.

When the wheelslip is of a more severe nature (greater and longer lasting unbalance), a level detection circuit is triggered by the voltage comparison bridge circuit. The level detection circuit senses the unbalance and feeds a signal to the comparator circuit which compares this signal and a taper circuit signal from the sensitivity adjustment and taper circuits. It then provides an energizing signal to a fast response Wheelslip Relay (WSX) to open the exciter shunt-field circuit. At the same time, the automatic sanding panel will provide sand to the rails. If the wheelslip lasts even longer, a slow response Wheelslip Relay (WSR) will be energized and additional corrective action will be taken to bleed additional current from the exciter shunt-field circuit. Also, a wheelslip indication light on the operator's control console will be lit.

To guard against simultaneous wheelslips and to protect against an overspeed condition, a third correction path is available. In this circuit a tachometer is located on one of the axles to monitor the speed. The speed sensing circuit

will sense the speed and feed the speed signal to an overspeed detector circuit. If an overspeed condition exists, the detector will energize the WSX circuit and, if necessary, will energize the WSR circuit to remove excitation, provide sanding and activate the wheelslip light.

DYNAMIC BRAKING SYSTEM

The dynamic braking system is explained in the "Dynamic Braking" part of the Braking Systems section in this publication.

The sequence of events that occur as the Throttle handle is moved to IDLE and the Braking handle is positioned is shown in Fig. VIII-14. This figure is divided into four operating conditions:

1. Throttle handle to IDLE.
2. Brake handle to SET-UP.
3. Brake handle to braking.
4. Brake handle between the minimum-maximum positions.

It should be noted that the events that occur as the handles are positioned occur at a fast rate and many events occur simultaneously. Also, for simplicity, all of the circuit configuration events are not shown.

ENGINE SYSTEMS MONITOR

DESCRIPTION

The Engine Systems Monitor (ESM) is a protective system that electrically, mechanically and automatically identifies improper locomotive conditions. Its function is to provide over-the-road reliability, avoid unnecessary shutdowns and reduce secondary failures. These objectives are accomplished by indicating when and what kind of maintenance work is required before the faulty condition causes a shutdown or road failure. Under most conditions, ESM will keep the diesel engine running, although load and speed may be reduced to match the unit's capabilities.

When a problem occurs, malfunction indicating lights on the Engine Control (EC) Panel in the operator's cab will be lit, either singly or in combination, to advise the crew and maintenance personnel that a problem has developed. Also, malfunction indicating lights on an Annunciator Panel located within the control compartment will be lit. By observing the indicating lights, comparing their pattern shown on an ESM Diagnostic Chart and checking the most probable cause, maintenance personnel can quickly analyze and correct the problem.

ESM DIAGNOSTIC CHART

The ESM Diagnostic Chart, Fig. VIII-15, presents a listing of indicating lights and system conditions including the most probable cause(s) of the problem.

When one or more ESM indicating lights on the EC Panel are lit, one or more indicating lights on the Annunciator Panel also will be lit. By comparing those illuminated with the chart, maintenance personnel can identify which line of the chart applies to the problem.

For example: if the NO BATTERY CHARGE, ANNUNCIATOR PANEL and CRANKCASE OVERPRESSURE lights are lit, Line No. 1 applies. Note that the EC PANEL LIGHTS column for Line No. 1 is divided into two sections. The top section lists the lights that are lit for a specific problem and alerts the train crew that some action may have to be taken. The bottom section lists the ANNUNCIATOR PANEL light which alerts maintenance personnel that a problem had occurred and further investigation is warranted. In this case, the action to be taken by the train crew is to reset the Crankcase Overpressure (COP) switch, (see ENGINE CONDITION column), in accordance with recommended railroad procedures.

The CRANKCASE OVERPRESSURE light on the Annunciator Panel (see ANNUNCIATOR PANEL column) will remain lit after COP is reset to indicate that the locomotive experienced a crankcase overpressure problem. After maintenance personnel have resolved the overpressure problem, the light on the Annunciator Panel can be turned-off by lifting-up the spring-loaded, RESET Toggle switch on the Annunciator Panel. This switch may be sealed with lockwire.

The ENGINE CONDITION column lists the various possible engine modes such as shutdown, idling or running.

The MOST PROBABLE CAUSE column lists the causes in descending order of probability. Thus, too high oil level in the crankcase would be considered the most probable cause; a plugged crankcase breather screen would be the least likely cause.

It should be noted that order of severity generally increases from Line No. 1 through Line No. 10. If an indication on one of the upper lines is ignored, expect progression to one of the lower.

The ESM Diagnostic Chart also has a column titled HOLD RELAY. This column lists the Engine Temperature Holding Relay (ETHR) and the Governor Shut Down Holding Relay (GSDHR). The ETHR relay will pick-up if

the engine experiences an engine overtemperature condition. This condition is usually caused by high lube-oil temperature, or low water pressure which causes the water temperature to increase above normal operating temperature. The GSDHR relay will pick-up if the engine experiences a very low oil pressure and/or very low water pressure condition, and the governor will then shut down the engine.

EQUIPMENT**Holding Relays**

The ETHR and GSDHR relays, Fig. VIII-16, are located within the control compartment near the Annunciator Panel. When the coil of either relay is energized, even momentarily, the relay mechanically latches in the closed (picked-up) position and a red light on its face is lit.

Even if the locomotive is shut down on the road and the battery switch is opened, the relay(s) will remain latched until manually reset. After the problem has been resolved, reset the relay by pushing the red tab on the relay labeled PUSH/RESET.

NOTE: Other holding relays and their applicable circuitry are available as optional equipment.

Engine Control Panel

The Engine Control Panel, Figs. VIII-17 and VIII-18, in the operator's cab contains ten malfunction indicating lights to warn the train crew and maintenance personnel that a problem has developed. When a problem occurs, the following ten lights will be lit either singly or in combination:

1. GROUND RELAY TRIPPED
2. OVERLOAD RELAY TRIPPED
3. NO BATTERY CHARGE
4. ENGINE OVERTEMPERATURE
5. ANNUNCIATOR PANEL
6. GOVERNOR SHUT DOWN
7. REDUCED EXCITATION
8. CRANKCASE OVERPRESSURE
9. ENGINE AIR FILTER
10. HOT DIODES.

NOTE: The Engine Control Panel can accommodate two, additional malfunction indicating lights as a customer option.

ENGINE SYSTEMS MONITOR DIAGNOSTIC CHART					
LINE NO.	EC PANEL LIGHTS (Throttle at IDLE)	CONTROL COMP. LIGHTS		ENGINE CONDITION (Unless Manually Shut Down)	CHECK EQUIPMENT LISTED FOR MOST PROBABLE CAUSE
		ANNUNC. PANEL	HOLD REL.		
1	NO BATT. CHARGE ANNUNC. PANEL CR'CASE OVER PR.			SHUTDOWN: will not crank until COP is reset. Indicates engine had excess crankcase pressure.	Too high oil level in crankcase, piston blow-by, plugged crankcase breather screen.
	ANNUNC. PANEL			RUNNING: indicates COP switch has tripped and been reset.	
2	ANNUNC. PANEL ENGINE AIR FILTER			IDLING: will not load. Indicates engine paper air filters excessively dirty.	Dirty engine paper air filters, blockage in primary air cleaners, debris obstructing engine air intake screens.
	ANNUNC. PANEL			RUNNING: may take full load. Indicates Engine Paper Filter Switch and Relay has tripped and been reset.	
3	ANNUNC. PANEL			RUNNING: may take full load. Indicates engine experienced low oil pressure.	Low oil level, dirty oil filter, open filter tank drain-back valve (C), dirty lube oil cooler — oil side, dirt in crankcase oil strainer, faulty lube oil relief valve, dirty fuel filter or strainer, failed (slipping) bonded pump drive, electrical bogging or overloading governor.
4	ANNUNC. PANEL			RUNNING: may take full load. Indicates engine experienced low oil pressure and high oil temperature.	Very dirty, almost plugged lube oil cooler — oil side. Also check all equipment listed on Lines 3 and 9. A more severe condition likely exists.
5	NO BATT. CHARGE ANNUNC. PANEL GOV. SHUTDOWN			SHUTDOWN: will not crank until reset. Indicates engine experienced very low oil pressure.	All equipment listed on Line 3. A more severe condition likely exists. Also investigate engine for failed lube oil pump.
6	ANNUNC. PANEL			RUNNING: may take full load. Indicates engine experienced low water pressure.	Low water level, cooling system not pressurized, dirty lube oil cooler — water side, water tank or lube oil cooler inlet screen plugged, dirty fuel filter or strainer, failed (slipping) bonded pump drive, governor.
7	ANNUNC. PANEL			RUNNING: may take full load. Indicates engine experienced low water pressure and high oil temperature.	Very dirty, almost plugged lube oil cooler — water side. Also check all equipment listed on Line 6 and 9. A more severe condition likely exists.
8	NO BATT. CHARGE ANNUNC. PANEL GOV. SHUTDOWN			SHUTDOWN: will not crank until reset. Indicates engine experienced very low water pressure.	All equipment listed on Line 6. A more severe condition likely exists. Also investigate engine for failed water pump.
9	ANNUNC. PANEL			RUNNING: may take full load. Indicates engine experienced high oil temperature.	Dirty radiators, plugged air inlet screens, excessive braking current, faulty control of water temperature, dirty lube oil cooler — either side, excess horsepower output. (May also be caused by very high ambient temperature or by tunnel operation.)
10	ENGINE OVERTEMP. ANNUNC. PANEL			IDLING: will not load. Indicates engine experienced very high water temperature.	Severe cooling system-related problem. If the system checks OK, test LOT switch. It may not be indicating that a high lube oil temperature has occurred. If LOT switch is found faulty, proceed to Line 11.
11	ENGINE OVERTEMP. ANNUNC. PANEL			IDLING: will not load. Indicates engine experienced very high oil or oil and water temperature.	All equipment listed on Line 9. A more severe condition likely exists. Also inspect for failed fan drive.
12	ENGINE OVERTEMP. ANNUNC. PANEL			IDLING: will not load. Indicates engine experienced low water pressure and very high water temperature.	Low water level.
13	OVERLOAD RELAY TRIPPED ANNUNC. PANEL			IDLING: will not load. Indicates main alternator experienced a surge of current. Reset GOLR to make unit operable.	Traction motors for signs of flashover; motors for shorted fields, busbars, or leads; bus bars and cables at main alternator and rectifier panels for loose connections; current limit adjustment in excitation panel; failure of ACCR; single-phasing of alternator; GOLR for defects; alternator field connections and busbars for a short circuit.
	ANNUNC. PANEL			RUNNING: may take full load. Indicates GOLR has tripped and been reset.	
14	GROUND RELAY TRIPPED ANNUNC. PANEL			IDLING: will not load. Indicates power circuits have experienced a ground.	Electrical power equipment for evidence of a flashover, intermittent ground, or continuing ground.
	ANNUNC. PANEL			RUNNING: may take full load. Indicates GR has tripped and been reset.	
15	ANNUNC. PANEL HOT DIODES			IDLING: will not load. Indicates one or more rectifier panels have experienced excessive temperature.	Main alternator for loose or missing covers, accumulation of debris on blower intake screens, inoperative blower, failed diodes in rectifier panels, single-phased alternator.
	ANNUNC. PANEL			RUNNING: may take full load. Indicates one or more hot diode detectors have tripped and relay has been reset.	
16	REDUCED EXCIT. ANNUNC. PANEL			RUNNING: will not take full load. Indicates problem in Excitation Panel causing operation in Reduced Excitation mode.	Excitation panel for proper cards in correct locations. Each card for dirty, bent, or broken contact pins. Faulty card. Allied circuits for loose or broken wires or components, including feedback connections from rectifier panels and ACCR to excitation panel. Make sure alternator is not single-phased. Make sure governor plug connection and wiring is correct.
	ANNUNC. PANEL			RUNNING: will take full load. Indicates some period of operation in Reduced Excitation mode, and switch on MD card has been reset.	

FIG. VIII-15. ENGINE SYSTEMS MONITOR DIAGNOSTIC CHART.

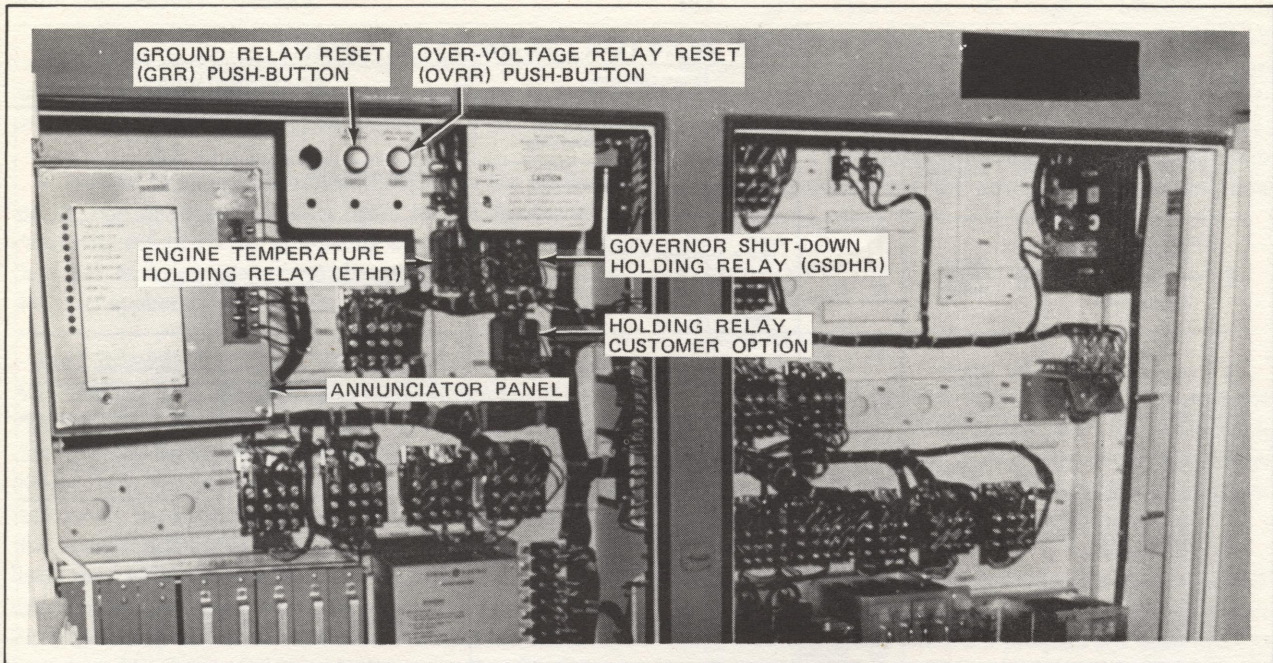


FIG. VIII-16. HOLDING RELAYS (SHOWN WITHIN THE CONTROL COMPARTMENT).

Annunciator Panel

The Annunciator Panel, Fig. VIII-19, located within the control compartment contains nine malfunction lights, a LAMP TEST push-button switch and a spring-loaded RESET Toggle switch. The panel is electrically connected directly to the locomotive battery so that if the locomotive is shut down and the battery switch is opened, the applicable malfunction light(s) will remain lit to alert

maintenance personnel that a problem has occurred. The nine lights are:

1. CRANKCASE OVERPRESSURE
2. ENGINE PAPER FILTER
3. LOW OIL PRESSURE
4. LOW WATER PRESSURE
5. LUBE OIL TEMPERATURE
6. GENERATOR OVERLOAD
7. GROUND RELAY
8. HOT DIODES
9. REDUCED EXCITATION.

A LAMP TEST push-button switch is provided to test the lamps. A RESET Toggle switch provides the means to turn-off the malfunction light(s) after the problem has been resolved. This switch may be sealed with lockwire.

NOTE: The Annunciator Panel can accommodate three, additional malfunction indicating lights as a customer option.

Modulating Control Governor

The major component in the Engine Systems Monitor is a modified control governor, Fig. VIII-20. The control governor is an electro-hydraulic device used to regulate speed and horsepower output of the diesel engine. It also includes a number of auxiliary devices to protect and provide the power plant with characteristics desirable for railway locomotive service.

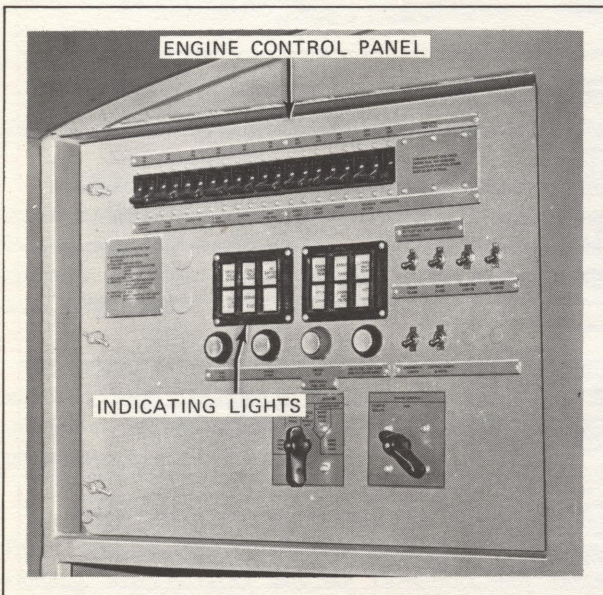


FIG. VIII-17. ENGINE CONTROL PANEL.

FIG. VIII-16, E-25039

FIG. VIII-17, E-25040

FIG. VIII-18, E-25041

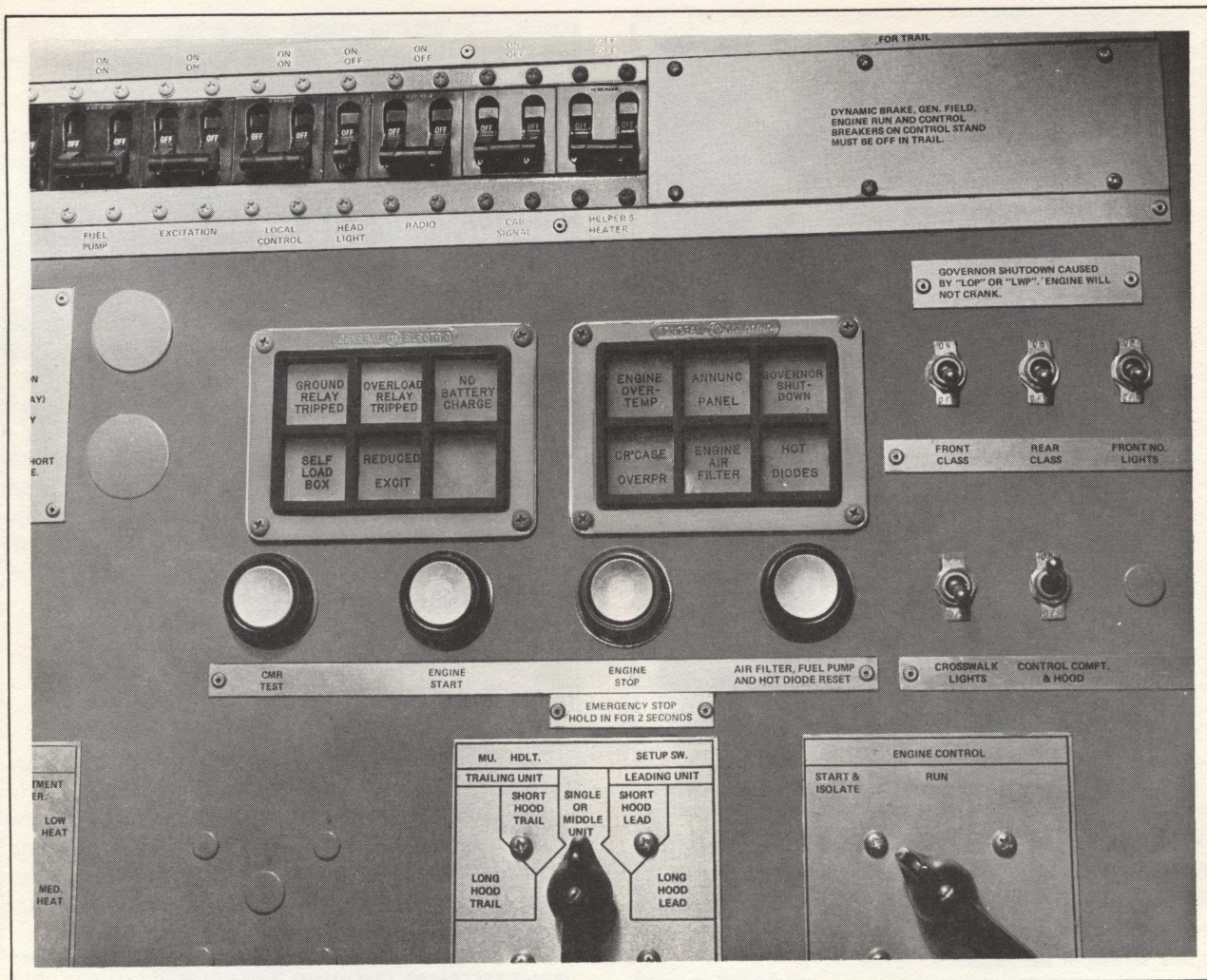


FIG. VIII-18. ENGINE CONTROL PANEL INDICATING LIGHTS.

FIG. VIII-19, E-25042

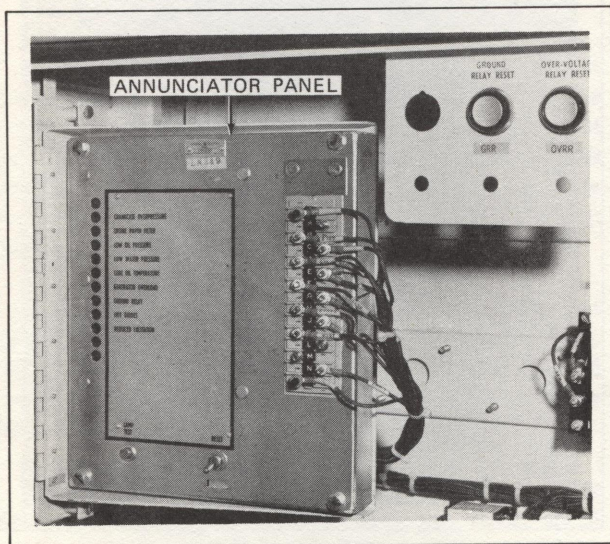


FIG. VIII-19. ANNUNCIATOR PANEL.

The governor is a self-contained unit which is mounted on and driven by the diesel engine. It is equipped with its own oil supply and oil pressure pump and is remotely controlled by the locomotive throttle.

During operation the governor performs two basic functions. Primarily, it controls the speed of the diesel engine by regulating the amount of fuel supplied to the engine cylinders. At any speed setting of the governor, speed control is isochronous; that is, the governor maintains constant engine speed regardless of changing conditions of load. The secondary function of the governor is to maintain a constant predetermined horsepower output of the engine for each specific speed setting by accurately controlling the engine load. Control of the engine load is accomplished by adjusting the strength of the generator field to compensate for electrical load changes on the generator, and those resulting from variable auxiliary loads such as the air compressor, battery charging generator, etc.

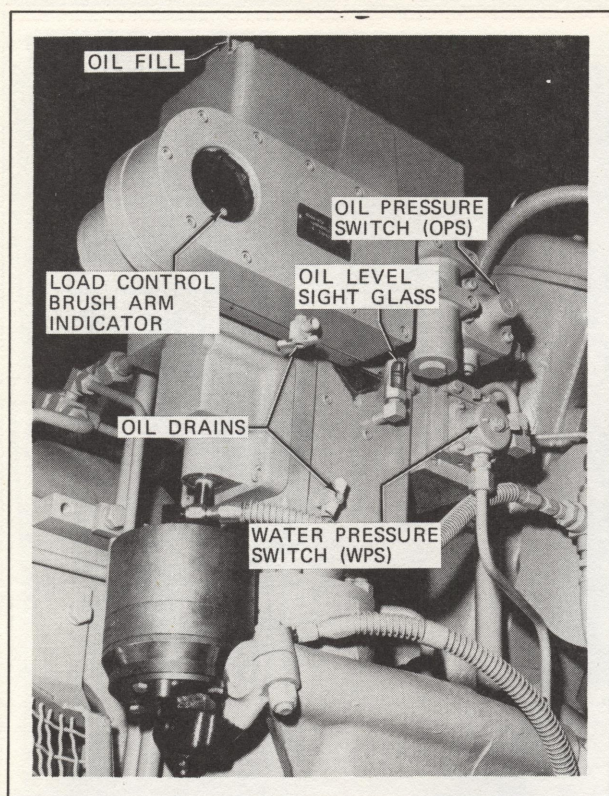


FIG. VIII-20. MODULATING CONTROL GOVERNOR.

Thus, while the primary function of the governor is to maintain speed of the engine by controlling both speed and load, a condition of balance can be established which results in a constant, single horsepower output for each speed setting of the engine.

The governor also has the following auxiliary functions:

1. Remote, electrical throttle control for eight notch speeds plus a SHUTDOWN position.
2. Overriding of the normal load control operation to aid in controlling wheelslip and, in some applications, dynamic braking functions.
3. Automatic shutdown of the diesel engine in the event of failure of the lubricating oil pressure or failure of the cooling water pressure. At idle speed a time delay is provided on these safety devices to permit starting the engine while still providing shutdown protection if the pressures fail to develop within the allotted time.
4. Limiting of fuel supplied to the engine during starting to provide improved starting characteristics.

Thus, the governor automatically reduces engine load and speed to match temporarily lower than normal lubricating oil or water pressure. When the temporary fault

condition returns to normal, the governor automatically permits reapplication of full load and speed. In motoring, no action by the operator is required.

In dynamic braking, all braking excitation is dropped and the diesel engine goes to IDLE when either lubricating oil or water pressure is low. After the temporary fault has been cleared, the operator can restore braking by moving the Braking handle to OFF and again advancing it in the braking mode.

If either oil or water pressure falls to the point that continued operation would be dangerous, the governor will shut down the engine.

Both derating and shutdown action is controlled by a bleed-off of speed-setting oil pressure within the governor. This bleed-off is actuated by engine lube oil and water pressure acting on their respective diaphragms. The diaphragms move plungers to regulate the bleed-off and operate the low Oil Pressure (OPS) and low Water Pressure Switches (WPS).

Temperature Switches

There are three temperature switches. Two switches, Fig. VIII-21, measure lube oil temperature out of the engine crankcase and are located externally near the outlet of the oil pump. The third measures water temperature, Fig. VIII-22, and is located on top of the water tank where water discharged by the diesel engine enters the temperature control equipment.

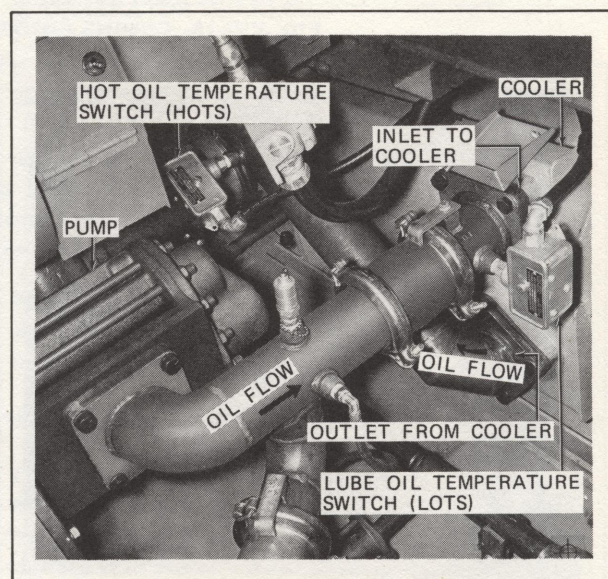


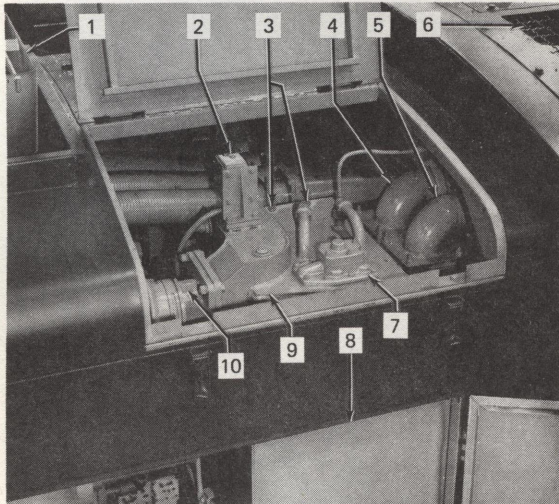
FIG. VIII-21. LOTS AND HOTS TEMPERATURE SWITCHES.

FIG. VIII-20, E-25043

FIG. VIII-21, E-25044

FIG. VIII-22, E-19692

FIG. VIII-23, E-21624



REF.	DESCRIPTION
1	ENGINE EXHAUST STACK
2	ENGINE TEMPERATURE SWITCH
3	PILOT VALVE ORIFICE INSPECTION PLUGS
4	WATER OUTLET, TO LEFT-BANK RADIATORS
5	WATER OUTLET, TO RIGHT-BANK RADIATORS
6	RADIATORS
7	THERMOSTATIC PILOT VALVE
8	WATER STORAGE TANK
9	FLUID-AMPLIFIER FLOW-CONTROL VALVE
10	WATER INLET TO FLOW-CONTROL VALVE

FIG. VIII-22. HOT WATER (ENGINE) TEMPERATURE SWITCH (HWTS) AND NEARBY COMPONENTS.

The Lube Oil Temperature Switch (LOTS) picks-up at 235 F. This switch is mounted in the oil inlet piping to the cooler. When it closes, the engine continues to run at designated speed. However, load (or dynamic braking) will be reduced to about two-thirds of normal for that Throttle notch. If lube oil temperature cools to 228 F, the switch drops-out and full load (or dynamic braking) is restored.

The Hot Oil Temperature Switch (HOTS) closes at 235 F. This switch is mounted in the cooler outlet piping. When it closes, all load is dropped, the alarm bell rings, and the engine speed returns to IDLE after 30 seconds. The alarm bell is then silenced.

The latching feature on the Engine Temperature Holding Relay (ETHR) maintains the no-load and IDLE speed condition until manually reset. This resetting should be performed after the cause of the problem has been resolved.

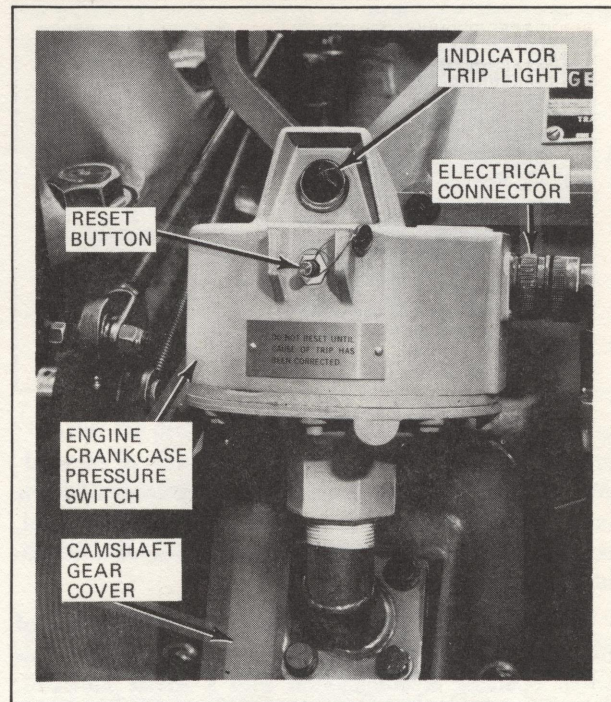


FIG. VIII-23. CRANKCASE OVERPRESSURE (COP) SWITCH.

The Hot Water Temperature Switch (HWTS) is set to pick-up at 235 F. Performance of HWTS is similar to HOTS; all load is dropped and engine speed returns to IDLE after 30 seconds. The alarm bell rings during this 30 second period.

Pressure Switches

The pressure switches consist of a Crankcase Overpressure (COP) switch, a low Oil Pressure Switch (OPS), a low Water Pressure Switch (WPS) and an Engine Filter Pressure Switch (EFPS).

The COP, Fig. VIII-23, is located on the left side of the diesel engine near the alternator. This switch protects the engine in case of excessive crankcase pressure. In normal operation, there is a slight vacuum in the engine crankcase. If a pressure of approximately 2 in. of water builds-up in the crankcase, the switch will trip and shut down the engine. A red indicating light is provided on the device (also on the EC Panel) to alert the operator when the switch is tripped. The switch can be reset by pushing the manual reset push-button located beneath the indicating light on the device after the cause of the trip is understood and corrected.

The OPS and WPS are located within the modulating governor, Fig. VIII-20. Their action will automatically

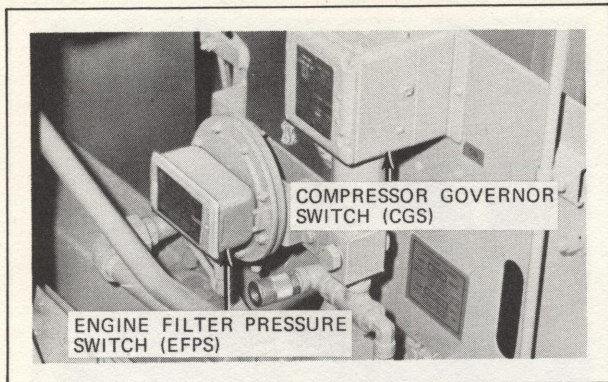


FIG. VIII-24. ENGINE FILTER PRESSURE SWITCH (EFPS).

reduce engine load and speed to match the low oil and/or water pressure. When the fault condition returns to normal, the switch(es) will automatically restore the locomotive to full load and speed.

The EFPS, Fig. VIII-24, is located on the right side of the locomotive in the air compressor compartment. This switch operates in conjunction with a service indicator, Fig. VIII-25. These two devices operate from the vacuum in the cleaned-air plenum. Dirt accumulation on the secondary air filter or primary air cleaner, Fig. VIII-26, will gradually cause the vacuum in the cleaned-air plenum to increase. It should be understood that the filters alone do not create a vacuum.

The vacuum is created by the suction of the turbo pulling clean air out of the cleaned-air plenum. As the paper filters become increasingly dirty, less outside air can enter the cleaned-air plenum to replace the air being pulled-out by the turbo, thereby, causing the vacuum pressure within the plenum to increase.

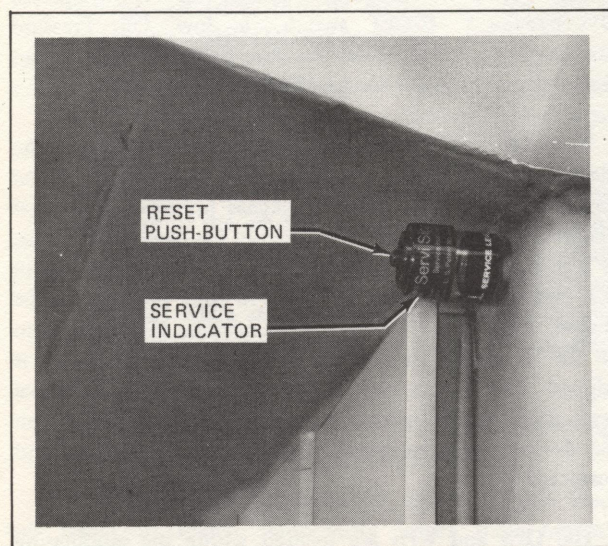


FIG. VIII-25. SERVICE INDICATOR.

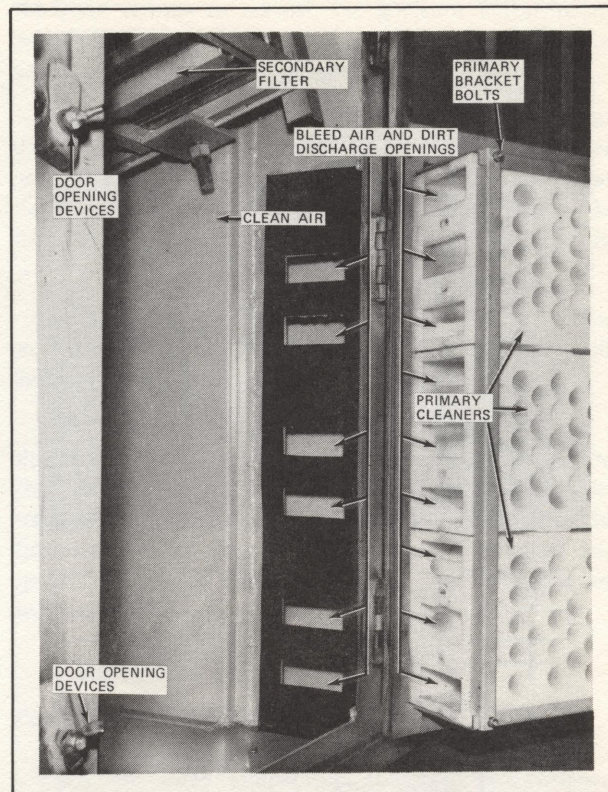


FIG. VIII-26. ENGINE-AIR FILTER ARRANGEMENT.

The service indicator, located high on the right-side of the locomotive, has a red band that gradually rises in the service-indicator window as the air filters start to get dirty, causing the vacuum to increase at full load on the engine. When the pressure reaches minus 12 in. water vacuum, the red band will lock in place and no longer drop when the engine is at idle. The red band movement is visible when the air filter is starting to get dirty and the engine is running at full load. After confirmation of this condition with a manometer, the filter elements should be changed. To reset the service indicator, push the reset button located on the service indicator.

If the filter elements are not changed, the vacuum in the cleaned-air plenum will increase at an accelerated rate. At minus 14 in. water vacuum, the Engine Filter Pressure Switch (EFPS) (sometimes referred to as the vacuum switch) will trip, the Engine Paper Filter Relay (EPFR) will be energized, and the engine will return to IDLE. Also, the ENGINE AIR FILTER light on the EC Panel will be lit and a trainline alarm will ring for 30 seconds. After the paper filters have been replaced and/or the air blocking debris has been removed, the EPFR relay can be reset by pushing the AIR FILTER, FUEL PUMP AND HOT DIODE RESET push-button on the EC Panel, Fig. VIII-18.

FIG. VIII-24, E-25045

FIG. VIII-25, E-22356A

FIG. VIII-26, E-15051

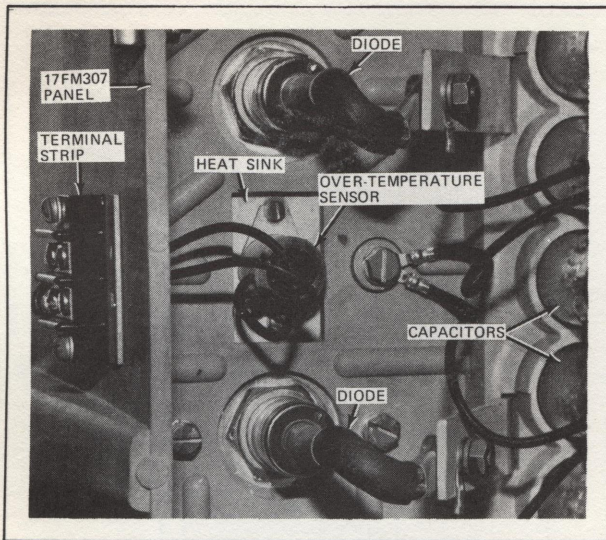


FIG. VIII-27. HOT DIODES SENSOR SHOWN IN A POWER RECTIFIER PANEL (TYPICAL).

Hot Diodes Sensor

Three hot diodes sensors, sometimes referred to as the rectifier Over Temperature Sensors (OTS), are mounted, one in each of the three power rectifier panels, Fig. VIII-27. These sensors react to a rise in temperature usually caused

by a lack of cooling air from the equipment blower or from an impending failure of a rectifier panel.

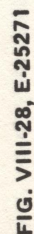
Activation of any of the three sensors will cause:

1. The Rectifier Over Temperature Relay (ROR) to be energized
2. The alternator to unload
3. The engine to return to idle speed after 30 seconds
4. The HOT DIODES light on the EC Panel to light
5. The trainline alarm bell to ring for 30 seconds.

After the problem has been resolved, the ROR relay can be reset by pushing the AIR FILTER, FUEL PUMP AND HOT DIODE RESET push-button on the EC Panel.

MONITOR CIRCUITS AND INDICATORS

The monitor circuits and indicators are shown on Fig. VIII-28. This figure lists the indicators (lights and alarms) located on the Engine Control Panel, Annunciator Panel and the operator's control console. It also defines the applicable monitor circuit for each indicator and the action that will result should the circuit be activated. As stated before, variations will exist between different models of locomotives and between railroad customers.



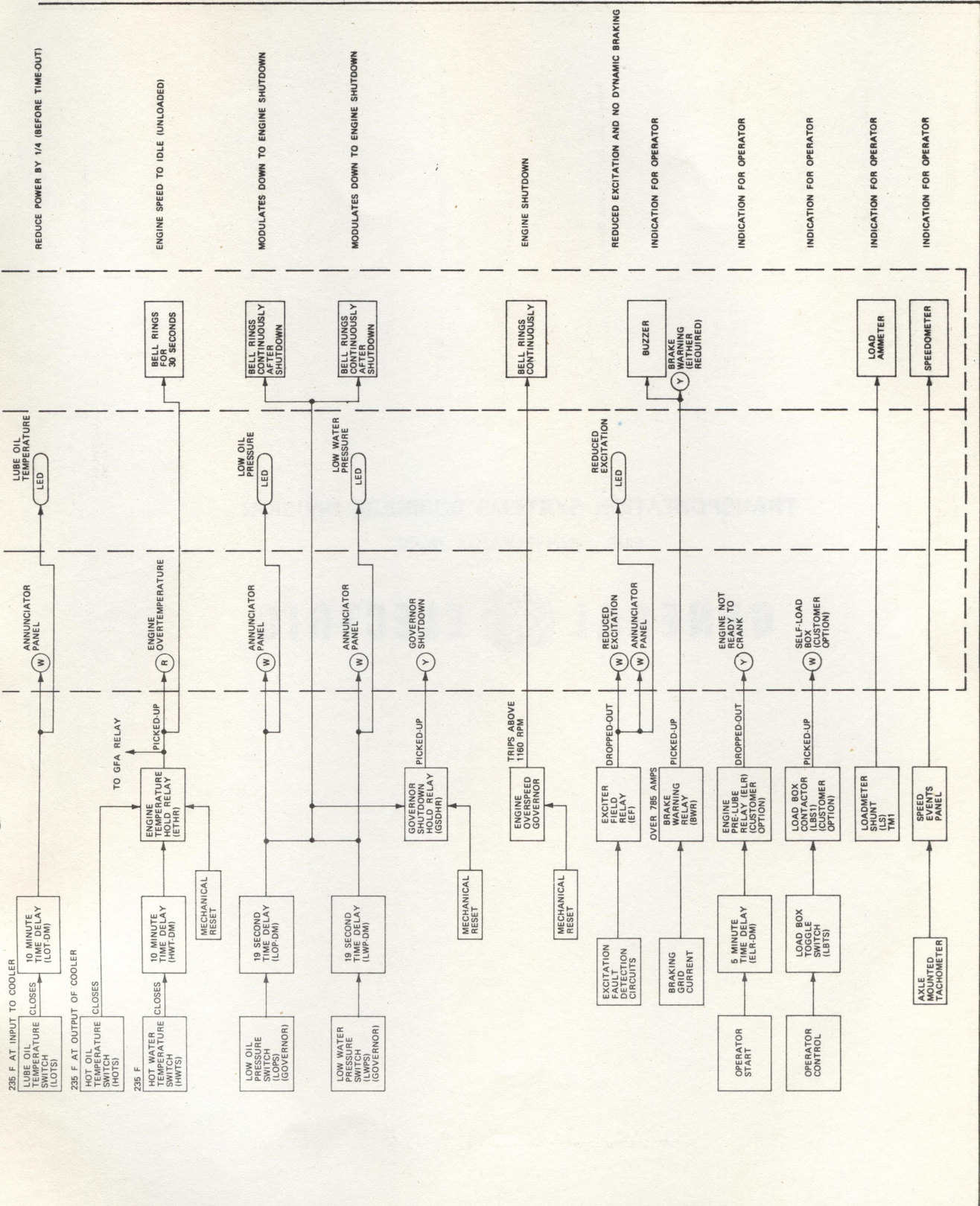


FIG. VIII-28. MONITOR CIRCUITS AND INDICATORS.